POWER PLANT ENGINEERING

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Tales—In and Out of School

AS WE LET our thoughts wander back through the dim and glorified past, we realize what an important part tales of travel, adventure and war, passed downward through the ages from generation to generation, played in supplying background for our somewhat sketchy knowledge of certain periods of history.

Even for comparatively recent times, the effect of the Canterbury Tales, Twice Told Tales and Tales of a Wayside Inn, is evident in rounding out our knowledge of the habits, thoughts and actions of people who lived in that period.

In the same manner, Electricity—What It Is and How It Acts, Part XXXIV of which starts on page 180, gives present day engineers a background of science which helps answer many of the questions which suggest themselves to engineers.

It seems that all things are made up of protons and electrons. Electrons, very small and active, are attached to protons in different numbers and formations to make atoms. Now, if the proper electron, a very small active one, be grasped with suitable kind of tongs, the remainder of the atom will shake itself loose and become something else.

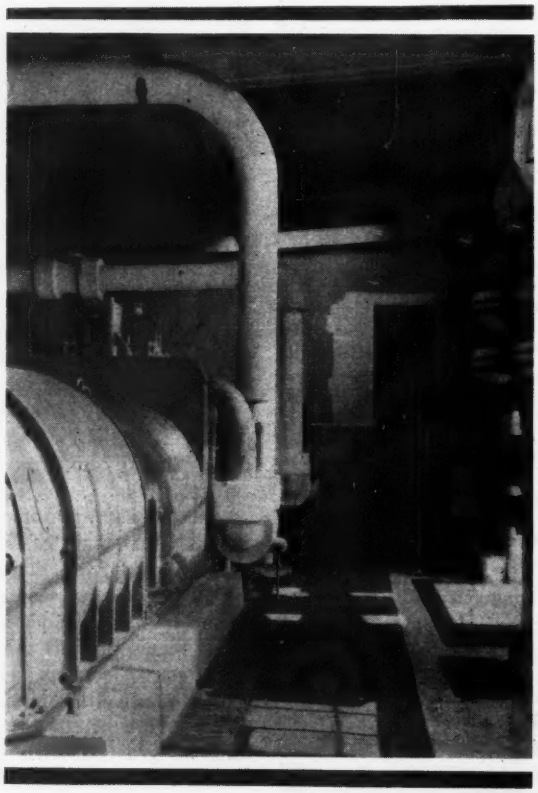
With commendable foresight, the U. S. Bureau of Biological Survey has applied this scientific principle in practice. They found that pocket gophers, a very destructive pest in certain parts of the country, had small active tails. Cutting off the tail, so that it could not vibrate, unbalanced the gopher and they vibrate so badly that they ultimately run into a fence post and kill themselves. Cutting off the tail changes a live gopher into a dead one.

The pile shown above is made of 66,038 gopher tails collected in gopher trapping contests in six Arizona counties, under the direction of D. A. Gilchrist. Every one of the gophers belonging to these tails is dead, proving the truth of the statement that when an electron is knocked off an atom a change takes place.

New Haven Pulp and Board Plant Uses 400 lb. Pressure

Four-hundred-pound boiler and non-condensing extraction turbine meet power demands of New Haven paper mill

INCORPORATING 400 LB. steam pressure, air preheating, forced and induced draft, water walls, evaporators and an extraction turbine, the new power plant of the New Haven Pulp and Board Co., at New Haven, Conn., is representative of the most modern practice in industrial power plant design. This plant, designed and constructed by Westcott and Mapes, Inc., of New Haven, has been in operation about nine months. It was built to replace an older installation which was no longer able to supply the growing load demands of the mill. The problems involved in the design and construction of this plant were those which confront the designer of almost any industrial power plant, that is, the new equipment had to be accommodated in the space available and the plant had to be kept in service while the new one was being built.



The New Haven Pulp and Board Co. is devoted to the manufacture of folding box board. The equipment installed consists of two paper machines with the necessary beaters, stock chests, jordans and other associated equipment. To supply this mill with electricity and steam, requires a fair size power plant.

In the manufacture of box board, the raw material, waste paper of various kinds, is treated with hot water in large open vats called beaters. The mixture of paper and water is circulated and beaten by means of flat bars set edgewise in a revolving cylinder until the paper is thoroughly broken up and the fibers more or less completely separated. At the conclusion of the beating process, the product is a sort of light fibrous pulp suspended in water. From the beaters the stock, as it is now called, is allowed to flow into the stock chests from which, in turn, it is pumped and forced through a jordan engine which breaks up any masses of fiber that still remain and is finally again pumped to small tanks which feed to the wet side of the paper machine. When the stock is finally collected on the felt of the paper machine, it contains about 80 per cent of water which must later all be driven off, first by passing through a series of rolls and later in the form of steam by passing the board over a number of steam heated drying cylinders.

All this requires considerable power and large quantities of steam. Until the new power plant was built, these power and steam requirements were met by an installation of a battery of small boilers operating at about 150 lb. steam pressure, a large Corliss engine and a steam turbine generator. The new installation now used, consists of a 400-lb. pressure water tube boiler with underfeed stoker and auxiliaries, and a non-condensing extraction turbine generator. This new equipment is now used exclusively, the old turbine and boilers being retained merely for spare or emergency operation. The Corliss engine was disposed of, the space it occupied being needed for the new boiler installation. The size of the new boiler was chosen largely because it could be accommodated in the existing space.

In arrangement the plant is simple, the new boiler room being located between the old boiler room and the turbine room. The latter is attractively decorated, the walls and ceiling being painted white, with a wainscoting around the entire room of white tile. The mechanical equipment is painted black.

An excellent idea of the general arrangement of the equipment may be had from the simple flow diagram shown in Fig. 4. Steam, it will be noted, is generated at about 380 lb. and is delivered to the turbine throttle and to the turbine driven boiler feed pump at that pressure. Since there is need for a considerable amount of low-pressure steam in the factory, the turbine operates, non-condensing, exhausting at a pressure of about

20-25 lb. This steam is used in the dryers and for other purposes in the paper mill.

There is also required in the mill, a certain amount of steam at 80 lb. pressure. This is obtained by bleeding the turbine at one of the low pressure stages as indicated. In case more low pressure steam (either 20 lb. or 80) is required than that supplied normally by the exhaust or the extraction stage of the turbine, an arrangement of reducing valves is installed whereby 380 lb. pressure steam is reduced to 80 lb. or 80 lb. reduced to 20 lb. A desuperheater is installed in the 380 lb. bypass line, as shown.

All condensate returns from the mill is delivered to an open deaerating feedwater heater which overflows into the distilled water storage tank. Makeup feedwater is evaporated, the output being delivered to the distilled water tank as shown.

Provisions for Coal Delivery and for Condensing and Process Water

The plant is located on the river front in the heart of New Haven's industrial area, convenient to an ample source of condensing water and to delivery either by truck, rail or water. At the present time, most of the coal is delivered by truck. This is dumped into a hopper which feeds into a bucket elevator and this in turn delivers the coal to the top of the boiler house where conveyors carry it either to the old boiler house or to the new one. These conveyors are belt conveyors made by the Fairfield Engineering Co., delivering direct to the overhead coal bins.

In the new boiler room, coal from the overhead bunkers drops by gravity onto an automatic electric scale where a record is secured of the weight of coal delivered to the stoker hopper. The stoker hopper is fitted with a Non-Seg coal spreader which insures an even distribution of coal throughout the lengths of the hopper.

All steam is supplied by a single new Bigelow-Hornsby boiler rated at 760 hp. This rating does not, however, include the economizer section which in this type of boiler is really a part of the boiler. The water heating surface in the boiler proper is 7595 sq. ft. while that in the economizer section is 1639 sq. ft., a total of 9234 sq. ft. The superheater is installed as shown on the section in Fig. 5. This superheater is capable of maintaining a total steam temperature of 615 deg.

FIG. 1. NEW POWER PLANT OF THE NEW HAVEN PULP AND BOARD CO.

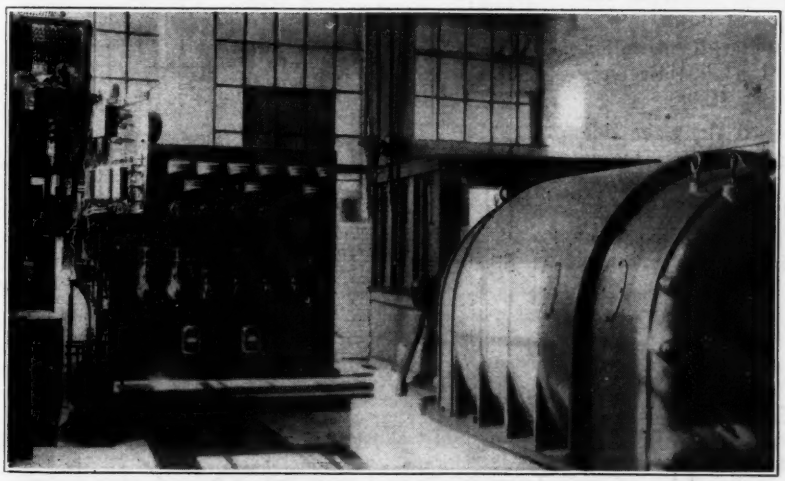


FIG. 2. A VIEW SHOWING THE NEW 2000-KW. GENERATOR AND A PORTION OF THE SWITCHBOARD

This boiler is fired by a Westinghouse, 8-retort, 33-tuyere underfeed stoker, driven by a 3-hp., 4-speed, 440-v. motor. The total projected grate area of the under and overfeed sections is 207 sq. ft. By means of a gear shift on the gear boxes, however, two speeds may be obtained on each motor speed. A separately-driven double roll clinker grinder and a power operated agitator is provided.

Ash discharged from the brick-lined ash hopper falls

directly into a scraper conveyor system which delivers it to a Link-Belt bucket elevator which in turn discharges directly into a steel ash bin outside of the boiler house. The ash hopper was built by the General Sheet Metal Wks., Bridgeport, Conn. In addition to the ash

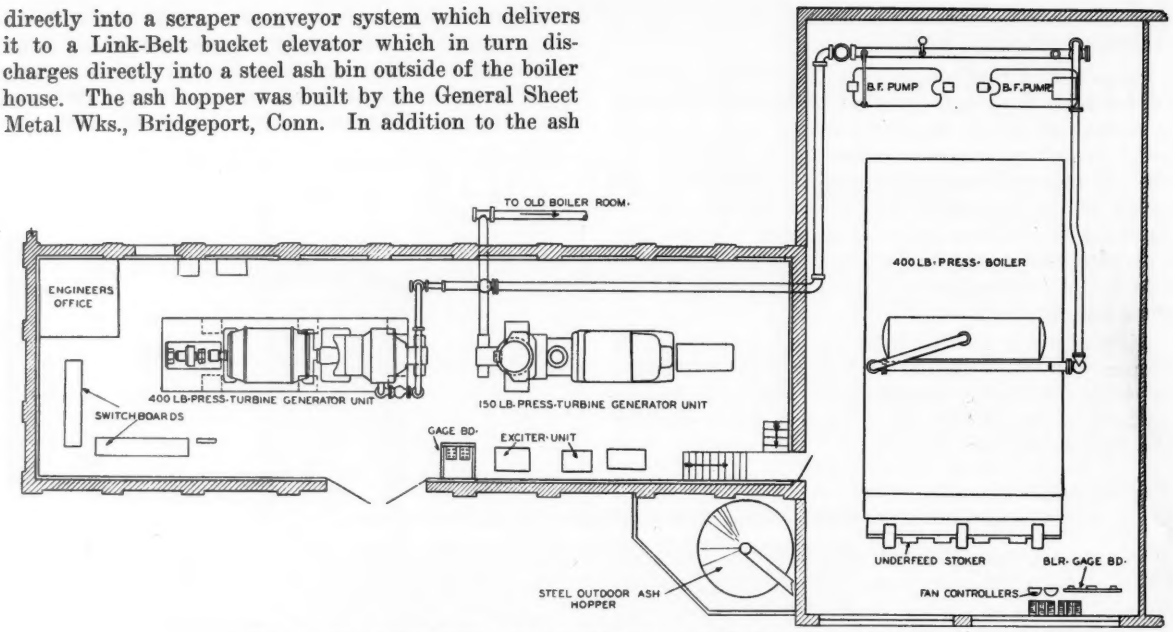


FIG. 3. PLAN SHOWING ARRANGEMENT OF BOILER AND TURBINES

hopper the boiler is fitted with dust discharge hoppers furnished by the Cooke Boiler Works.

The furnace was built by Geo. Allen and Sons. It has a volume of 4800 cu. ft. and is provided with Bigelow water walls and arch and also a water-cooled bridgewall. This bridgewall consists of 24 3¼-in. dia. No. 8 gage tubes, 20 ft. long, the lower 8 ft. being covered with cast-iron blocks. Above these cast-iron blocks the bridgewall is lined for about four feet with Nygaard blocks. Originally, the upper part of tubes in the water-cooled bridgewall was left bare but it was found advisable later to protect them from the direct action of the flame, so they were covered with a plastic refractory. The total water surface is 824 sq. ft.

Bernitz carborundum blocks are used along the side walls at the stoker level and two rows of three blocks are placed across the front wall. Above the Bernitz blocks, the furnace walls are lined with B. & W. 80 brick and backed with "Woodland." The furnace has both vertical and horizontal expansion joints.

Fittings on the boiler include the following equipment:

1 Ashcroft double spring 12-in. steam gage.
1 Reliance alarm water column.
3 ¾-in. P. B. Huyette flanged gage cocks.

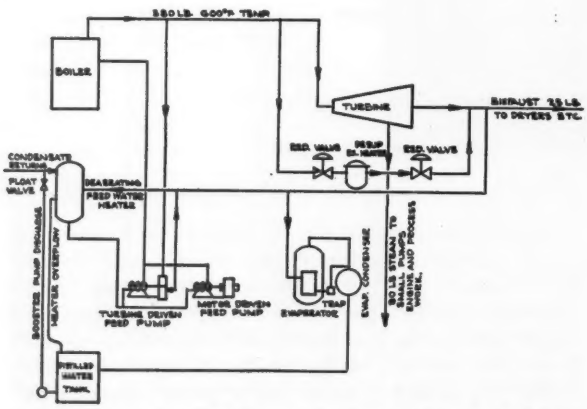


FIG. 4. SIMPLIFIED FLOW DIAGRAM OF THE HIGH PRESSURE STEAM SYSTEM

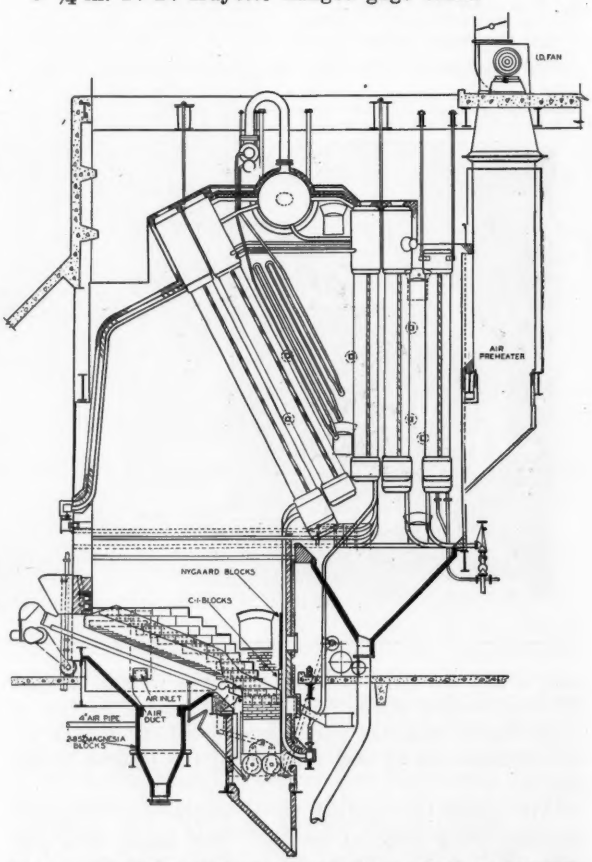


FIG. 5. THE NEW BOILER IS EQUIPPED WITH AN UNDERFEED STOKER AND HAS A WATER-COOLED BRIDGEWALL

1 P. B. Huyette flanged water gage.
5 Yarway seatless cast steel, 2½-in. blowoff valves.
1 Yarway seatless master 2½-in. blowoff valve.
8 Diamond soot blowers.
3 Consolidated safety valves.

Two of these are on the boiler, set to pop at about 405 lb. and the other is on the superheater set at about 400 lb.

Feedwater level in the boiler is controlled by S-C. feedwater regulators.

Forced and Induced Draft Equipment

Both the forced and induced draft fans are located on a floor above the boiler. The induced draft fan is placed to discharge directly into the stack. The forced draft fan takes air from the upper part of the boiler room and forces it into the air preheater. The latter is of the flat plate, counterflow type and has a total heating surface of 6600 sq. ft. It contains 54 chambers, 4 ft. deep by 15 ft. 3 in. long, each chamber being formed of 2 No. 11 special corrosion resisting copper steel sheets placed so as to form an air space ¾ in. wide. The elements are placed to form gas spaces also ¾ in. wide.

Forced draft is produced by a Sturtevant, design 5, size No. 80, double width, double inlet, full housing, vertical down discharge fan. It is driven by a 50-hp., 1800-r.p.m., 440-v. General Electric Co. motor, through a Fast flexible coupling. The induced draft fan is also a Sturtevant fan, this unit, however, being designated as the No. 7, design 3, multivane type. It has double width, double inlet boxes. This fan is driven by a 50-hp., 900-r.p.m. General Electric motor. The forced draft fan delivers 23,000 c.f.m. at 70 deg. F. and 9.45 in. static pressure and the induced draft fan 35,000 c.f.m. at 275 deg. F., at 2.8 in. static pressure.

Under normal conditions of operation, air enters the air heater at about 115 deg. and is delivered to the furnace at from 220 to 240 deg. The gas temperature entering the air heater is about 440 deg. and leaving, about 277 deg. These temperatures are for a flow of gas equal to 80,000 lb. per hr.

Boiler Feedwater

Boiler feed make-up is city water. This is evaporated in a Foster Wheeler evaporator having a capacity of 7500 lb. of condensate per hr. The condensate is delivered to a distilled water storage tank, from which it is pumped by a small booster pump to the deaerating feedwater heater, into which all returns from the mill are delivered. In the feedwater heater, which is a Cochrane unit of 75,000 lb. per hr. capacity, the temperature of the water is raised to from 225 to 230 deg. and at that temperature is pumped into the boiler.

Two boiler feed pumps are provided, one being a turbine driven and the other motor driven. Both units are Pennsylvania Pump and Compressor Co. units motor driven operating at 1750 r.p.m., turbine driven 2400 r.p.m. and delivering 200 g.p.m. under a 1055 ft. head. The drive for the steam driven unit is a 90-hp., 370-lb. non-condensing Terry turbine. Both feed pumps are located behind the boilers, on the operating floor so that

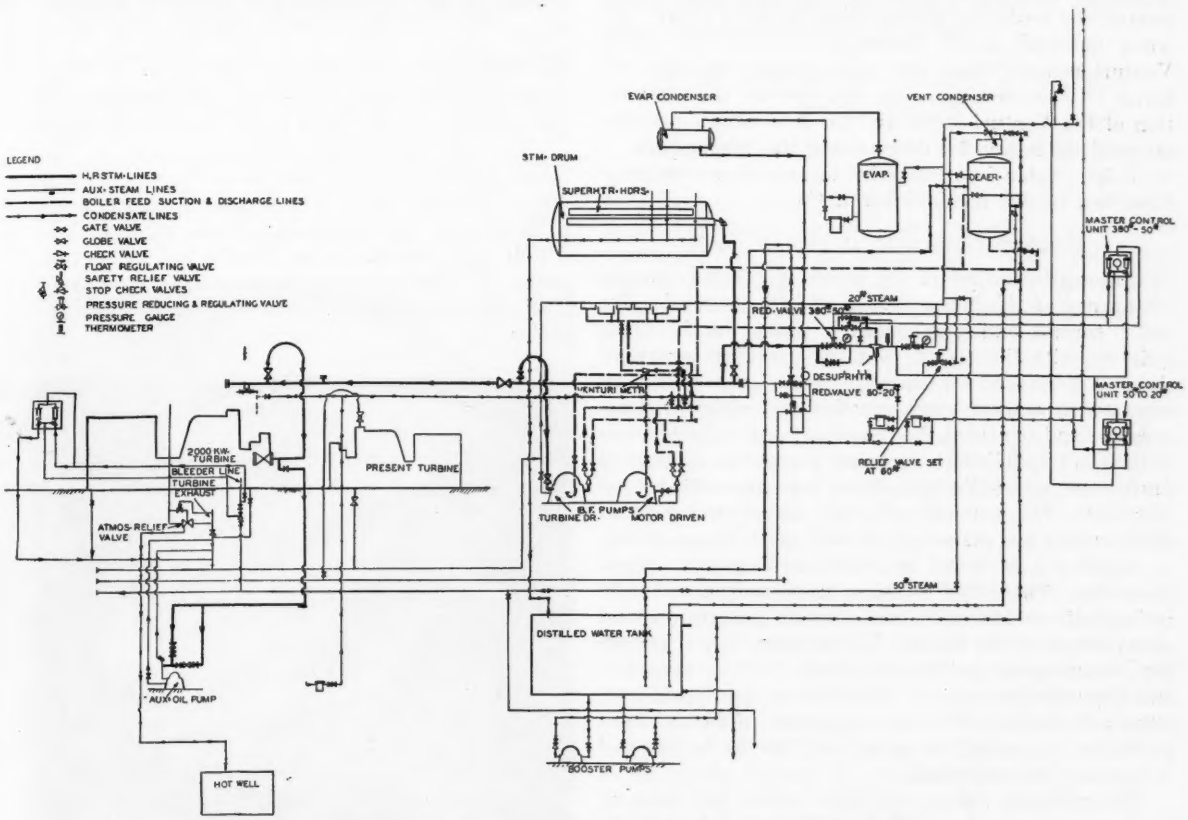


FIG. 6. DIAGRAM SHOWING STEAM AND WATER CONNECTIONS

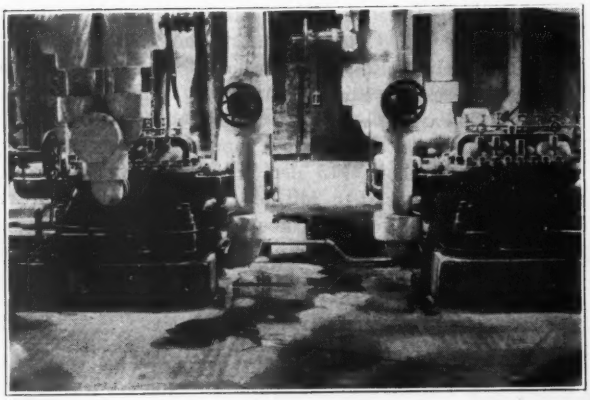


FIG. 7. TWO BOILER FEED PUMPS ARE PROVIDED, ONE MOTOR DRIVEN AND ONE TURBINE DRIVEN

a positive head is obtained on the suction side of the pumps, the feedwater heater being installed above. All water delivered to the boilers is measured by a 3-in. Venturi meter. Since the entire steam output of the boiler is measured by steam flow meters, the combination of the Venturi meter and the flow meters provides an excellent means for determining the evaporation.

Boiler water is treated by means of a compound furnished by W. B. McVicker & Co.

Control Equipment in Boiler Room

Automatic control of the boiler is effected through the agency of the Smoot system of boiler control. The boiler control and gage board is placed in the firing aisle opposite the boiler. On the panel are arranged three Ashcroft steam pressure gages, one indicating saturated steam pressure, another superheated steam pressure and the third, feedwater pressure. In addition to these, a Republic CO_2 recorder, a Republic six-pointer draft gage, and a Foxboro steam pressure recorder are provided. The controllers for the forced and induced draft motors are placed at the side of this gage board.

Another gage board is located on a gallery behind the boiler. This panel contains the recording and indicating instruments which measure the temperature and steam output of the boiler. It comprises Bristol recording pressure gages and thermometers, Foxboro recorders and Republic flow meters. Bristol recording liquid level gages are also provided for the purpose of furnishing a permanent record of the water level in the boilers and in the distilled water tank.

The reducing valves and relief valves for reducing the steam pressure from 400 lb. to 80 lb. and from 80 lb. to 20 lb. are located next to this panel where they can be adjusted conveniently. A relief valve is set in both the 80 and 20-lb. steam lines. If the pressure in the 80-lb. line builds up, the relief valve operates (through an S-C control) and discharges into the 20-lb. line. If the pressure in the 20-lb. line is too high, the relief valve in this line acts and discharges the steam into the atmosphere.

Turbine Generator Data

Both the old and the new turbines are installed in the present turbine room. The old machine is a General Electric Curtis unit of 1250 kw. capacity generating current at 480 v. and operating at 3600 r.p.m. This unit calls for a pressure of 150 lb. at the throttle. At

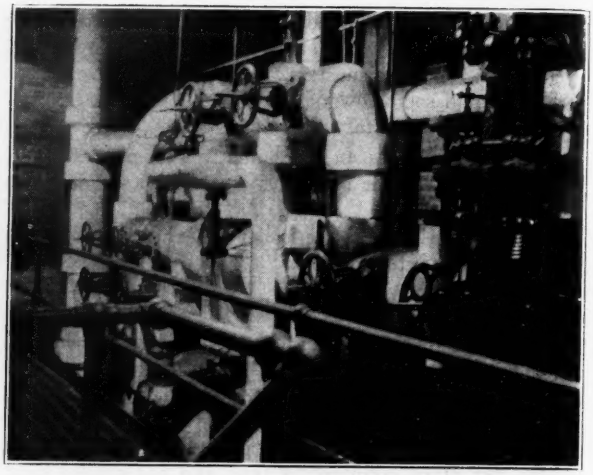


FIG. 8. PIPING ARRANGEMENT BEHIND BOILER, FOR REDUCING FROM 400 LB. TO 80 LB. AND 20 LB.

the present time this machine is not used but is held in reserve for emergency operation. It operates condensing, being provided with a C. H. Wheeler jet condenser.

The new turbine generator consists of a Westinghouse, 2000 kw., 80 per cent power factor (2500 kv-a.) 480 v., 3-phase, 60-cycle generator direct-connected to a 3600-r.p.m. non-condensing steam turbine built for 370 lb. gage pressure at the throttle and 160 deg. superheat. It is bled at about 80 lb. and exhausts at 20 lb. The generator is fitted with a Griscom-Russell U-fin air cooler.

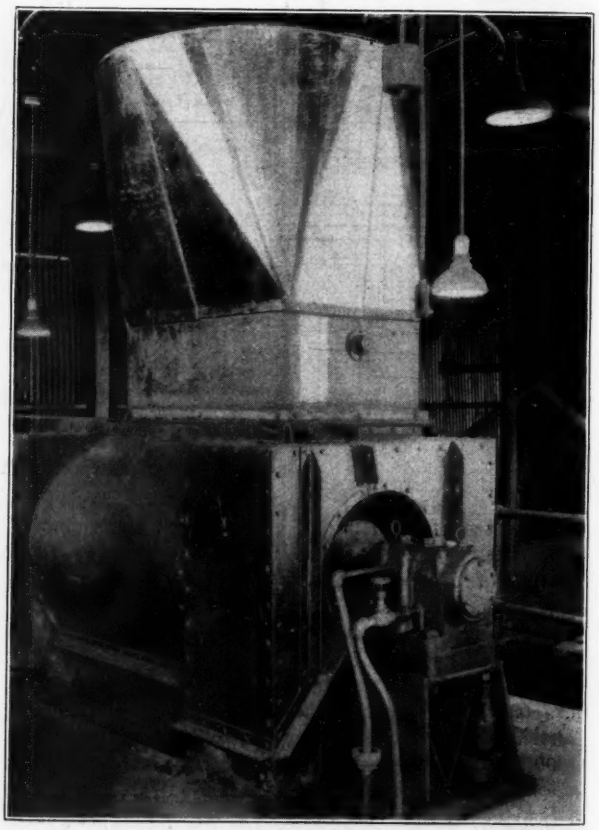


FIG. 9. THE INDUCED DRAFT FANS

Excitation current is furnished by a direct-connected exciter rated at 17 kw.

The generator is designed for the following water rates at various loads: 28.75 lb. of steam per kw-hr. at 1000 kw., 80 per cent power factor, 25.65 lb. at 1500 kw. and 24.2 lb. at 2000 kw. With 370 lb. gage steam pressure and 160 deg. superheat at the throttle, with 20 lb. back pressure and bleeding non-automatically, the performance of the turbine is as follows:

Kw. Load	1000	1500	2000
Total steam to throttle, lb. per hr.	31,590	42,250	52,690
Steam bled, lb. per hr.	8,000	8,000	8,000
Steam exhausted, lb. per hr.	23,590	34,250	44,690
Bleeder pressure, lb. abs.	76.0	98.5	121.0

Conclusion

This plant was designed for a maximum steam output of 84,000 lb. per hr. or a combustion rate of approximately 40 lb. of coal per sq. ft. of stoker surface per hr. Since its completion, with the exception of a few minor troubles, the plant has operated satisfactorily. By means of this new boiler installation, the boiler room operating force was reduced from 22 to 9 men and the coal consumption at which the plant has been running is about 60 per cent of that previously prevailing.

Coal used is New River slack, running about 14,400 B.t.u. per lb. and with about 2.5 to 5 per cent moisture. This, when necessary, is crushed to 1½ in. An air pressure in the supply line to the furnace of 1½ in. is carried and at a rating of 250 per cent, the air temperature maintained is about 230 deg. Air and gas temperatures in the air preheater have already been discussed. The temperature of the gas entering the economizer section of the boiler is about 520 deg.

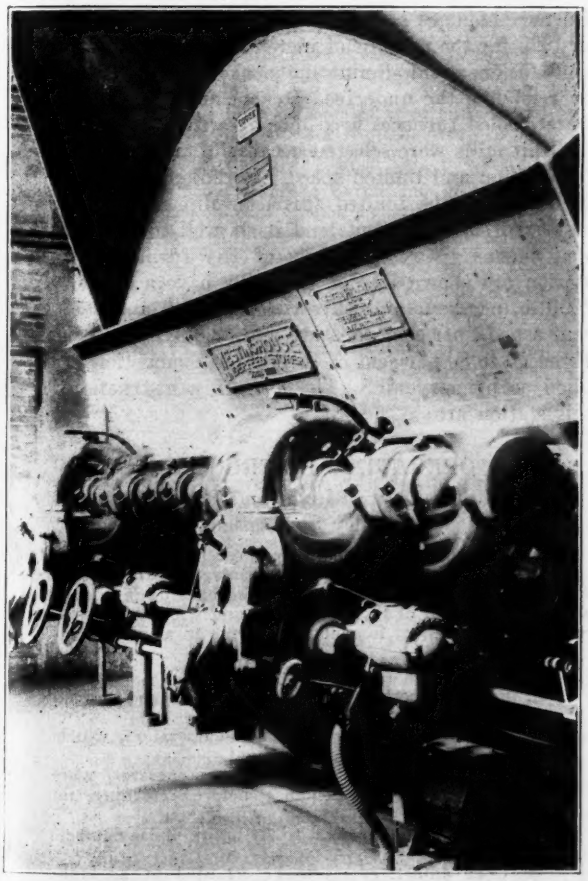


FIG. 10. STOKER HOPPER IS FITTED WITH A COAL SPREADER WHICH INSURES AN EVEN DISTRIBUTION OF COAL IN THE HOPPER

At 250 per cent rating a superheat of 160 deg. is carried or a total temperature of 600 deg. Maximum B.t.u. liberated per cu. ft. per hr. is 18,000.

Boilers are blown down about every 4 hr., the limit of concentration permissible being 120 grains per gal.

In concluding this description, we acknowledge our indebtedness for many courtesies extended and assistance rendered in supplying data on which this description is based, to Wm. Gaylord, of Westcott and Mapes, Inc., the designing engineers, and to H. D. Fisher, plant engineer of the New Haven Pulp and Board Co., under whose direction the plant is operated and whose ideas are incorporated in its design.

High Pressure Steam Progress in Germany

Since 1922, no fewer than 274 boilers designed to work at pressures exceeding 420 lb. per sq. in. have been put into service in Germany, the number including several examples designed for working pressures between 700 and 1400 lb. per sq. in. Electric power stations are leading the way in the adoption of high pressure steam; there are now quite a number equipped with 560-lb. boilers. The latter are, owing to their relatively high cost, usually of small size and used to meet the requirements of the base load of the power station; large, medium pressure boilers, also steam accumulators are employed to meet any variations in electric power supply demand. Boilers with a heating surface of from 4300 to 6450-sq. ft. heating surface are the most numerous; in power stations of about 50,000-kw. capacity, the heating surface of the boilers usually ranges from 7500 to 10,700 sq. ft; while in 100,000-kw. generating stations, boilers with a heating surface ranging from 16,000 to 21,500 sq. ft. are employed. The steaming capacity of the boilers used in Germany is also steadily increasing, capacity of 1000 lb. per 100 sq. ft. per hour being now quite common. At the electric power station at Mannheim the boilers working at 1420 lb. per sq. in. are raising about 1700 lb. of steam per 100 sq. ft. per hour.

In 1676, Robert Hooke discovered that the strain in a body is accurately proportional to the stress. Thus the elongation of a wire is proportional to the tension applied or the shortening of a loaded column is proportional to the load. This so-called Hooke's Law is quite accurate for elastic substances like steel but does not apply to plastic substances. Even elastic bodies like steel follow the law only over a definite range or limit called the elastic limit, beyond which point the wire or steel elongates faster than the force or tension is increased and will not return to its original length but retains a permanent set. Modern research with delicate instruments has shown that Hooke's Law is only an approximation but is close enough to be extremely useful for practical engineering purposes.

Safety Rules Essential for Pulverized Fuel Plants

Operating Codes Prepared by E. H. Tenney, Chief Engineer of Power Plants of the Union Electric Light & Power Co., Summarize Good Practice and Have Prevented Accidents at Ashley Street and Cahokia

ALTHOUGH ACCIDENTS, brought about by explosions and fires in pulverized coal plants, are not common, they are an ever present source of danger and can be avoided only by care and diligence on the part of operators and designers.

That such a danger does exist is testified for by the elaborate interlocking systems provided in the modern plant to insure proper starting sequence of equipment; by the safety codes and building ordinances; by insurance rates; by the recent investigation started jointly by consulting engineers, manufacturers and operators to dig into and determine the cause of explosions and last by the occasional explosion that does occur sometimes with fatal results.

Engineers familiar with the situation have been well aware of the dangers and have taken steps to see that the men operating equipment were instructed in the dangers of improper methods and thoroughly conversant with the proper ones. Because of the continued growth of pulverized coal and its increasing popularity, the following operating codes are reproduced for the benefit of those who may be using pulverized coal for the first time and for those contemplating its use.

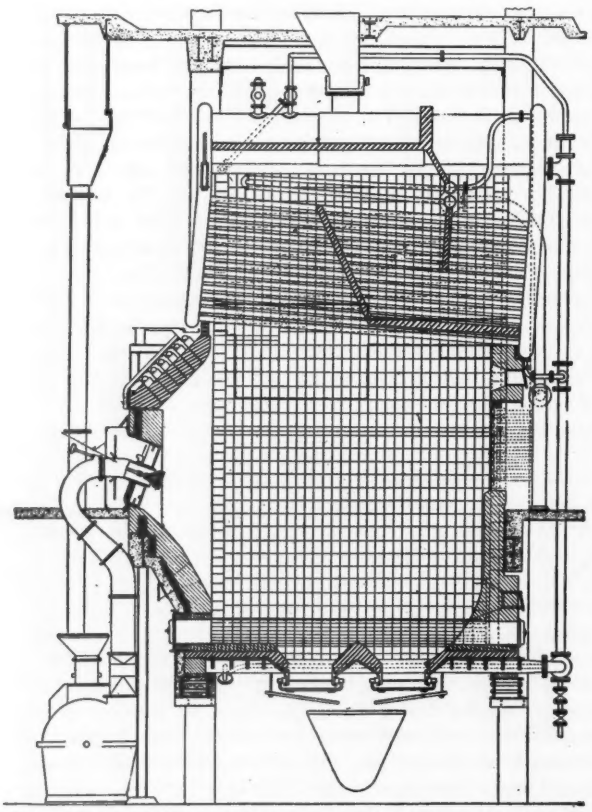


FIG. 1. FURNACE AND MILL ARRANGEMENT AT ASHLEY STREET STATION

These codes are not new; with revisions, they have been in use many years and signed by E. H. Tenney, Chief Engineer of Power Plants of the Union Electric Light & Power Co. of St. Louis. Both the unit system and bin system are covered, the unit system as installed at Ashley Street Station and the bin system as installed in the first two sections of Cahokia.

Both of these stations are pioneers in the field of pulverized coal. Cahokia was one of the first large pulverized coal fired plants built in this country while Ashley Street was one of the first important unit mill installations and development work carried on there with the Bailey-Tenney burner was largely responsible for the growth and appreciation of the benefits of the turbulent burner.

Both Unit and Central Systems Covered

Although the instructions as a rule are in a general form, some reference is made to specific equipment and for this reason a short review of the station is given. Furnace changes at Ashley Street Station were started in 1925 for the purpose of increasing the boiler capacity and efficiency and eliminating smoke. This was effected by removing the underfeed stokers and building larger water-cooled furnaces fired by pulverized fuel.

Unit mills were selected because of the lower cost of installation and limited space. Turbulent burners were used because the limited furnace volume and more or less fixed shape did not lend itself well to the straight shot burner. Cross sections of the furnaces at this station are shown in Fig. 1. Mills have a capacity of 2000 lb. per hour and pulverize coal with about 13 per cent ash, 12 per cent moisture and 33.8 per cent volatile. From 50 to 80 per cent of the air for combustion is supplied as primary air.[1] The operating instructions for this station are:

OPERATING INSTRUCTIONS

Union Electric Light and Power Co.
Ashley St. Station

Employes are urged to observe these rules concerning the operation of pulverizing mills and pulverized fuel furnaces. Attention is particularly directed to the hazards in connection with the operation of this equipment and your co-operation is requested in an effort to reduce accidents to a minimum.

LIGHTING FIRES

1. Furnace operator will go to basement and inspect mill before starting.
2. Magnetic separator must be in operation, which will be indicated by pilot light.
3. Mill is to be started by furnace operator, who will observe performance before returning to firing floor.
4. Draft is to be brought to .04 in. by boiler damper regulation.
5. Cone adjustment is to be set at 1 in. as indicated by scale on push rods. Air ports, clean-

[1]For additional details, see Power Plant Engineering, March 15, 1926, page 362.

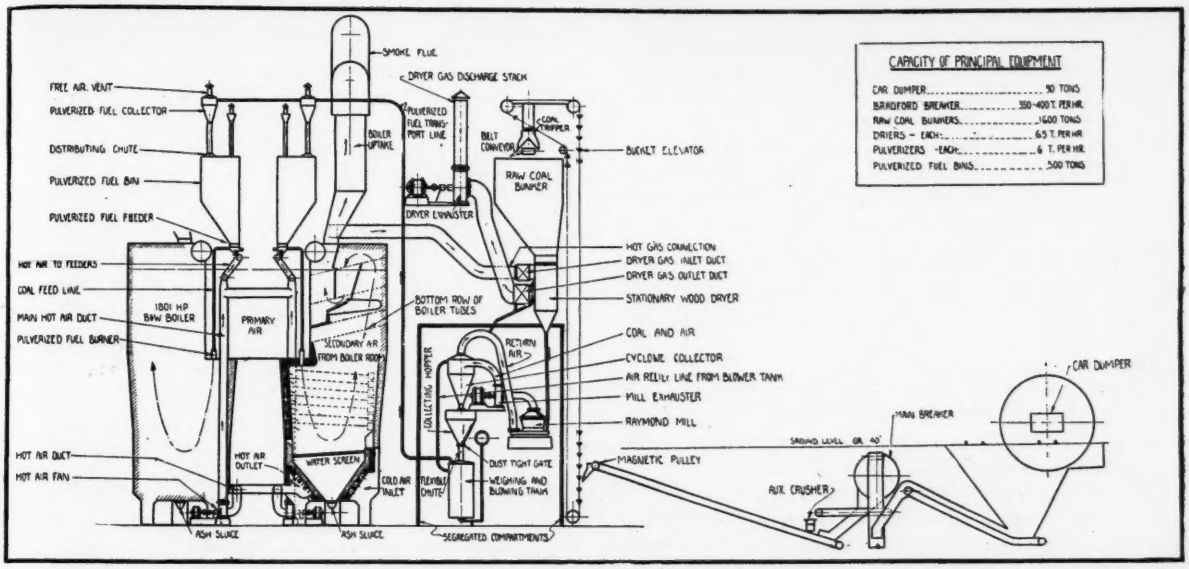


FIG. 2. CROSS SECTION OF THE BOILER AND COAL HANDLING EQUIPMENT IN THE FIRST SECTION OF CAHOKIA AS IT WAS IN 1924

out doors, burner dampers and pulverizer dampers are to be tightly closed before starting.

6. Ignition torch is to be inserted through air port below burner. Particular attention is directed to the NECESSITY FOR LIGHTING THIS TORCH BEFORE COAL FEED IS STARTED. This is probably the most dangerous feature in connection with the operation of these boilers.
7. Start coal feed motor by means of rheostat on panel board. Usual point for best ignition is 25 per cent full speed.
8. Care must be taken to keep clear of burners and other openings in furnace front in case fire and smoke "puffs" out as coal ignites.
9. Care must be taken to prevent visitors or other employes from standing or passing in front of boiler when boiler is being lighted.
10. As furnace heats up, cone adjusters are to be pushed in to regular operating position (usually about 5 in.)
11. Water tender should be notified of boiler going on load in order that he may watch water level closely.
12. Inspect all gage board instruments, steam flow, air flow, draft gages, and see that all are operating properly or reported to Combustion Engineer.

OPERATION

13. Pulverized fuel furnaces are very sensitive and are subject to very fine adjustment, therefore skillful operation is required for best economy and absence of SMOKE.
14. The principal means of control is the steam flow meter. These flow lines must be kept together at all times.
15. The flow of coal from each burner must be observed and, if necessary, dampers adjusted to give uniform and equal quantities of coal through each burner.
16. Fineness of grind can be estimated from observation, and any variation from normal shall be immediately reported to Combustion Engineer and Boiler House Engineer, who will determine cause and consult maintenance foreman.
17. Care must be exercised in the changing of air adjustments. Variations in rating require changes in primary air through pulverizer and secondary air adjustments by means of burner housing adjustment and remote control on air ports. These adjustments must be diligently followed up during load fluctuations.
18. One of the principal features of this method of firing is the possibility of controlling combustion to the extent that SMOKELESS operation will result. Emission of smoke from these furnaces will not be permitted, and operators not qualified to handle these boilers without smoking after reasonable experience will be replaced.
19. Furnace operators will be responsible for the proper cleaning of furnaces. Ash is not to be permitted to accumulate beyond reasonable and predetermined depth in the furnace, and furnaces must be cleaned at regular intervals.

TROUBLE

20. In case of trouble on any part of the pulverizer or boiler equipment, operator will immediately stop the pulverizer by means of the emergency cut-out switch on panel board, if observed from the operating floor, or the oiler on pulverizer will stop the machine by means of the starting compensator if the trouble is on the pulverizer and observed by the oiler from below.
21. Engineer is to be notified immediately who will, if necessary, confer with Maintenance Foreman.
22. In case of temporary outage, the complete cycle of starting as indicated above shall be observed.
23. In no case shall pulverizer be started up without the use of lighting torch, as above outlined. This is a very important point and shall be carefully observed by all employes.
24. Starting of the pulverizer after a short outage, thereby discharging pulverized coal into a hot furnace is very dangerous, therefore, utmost care must be exercised in putting a pulverizer back in service after a short outage.

MAINTENANCE

25. The maintenance foreman will be responsible for the mechanical condition of the pulverizer equipment.
26. Log shall be kept of all work done on each individual machine. The maintenance foreman shall obtain from the operating Engineer the hours each machine is on the load and the estimated coal pulverized.
27. The Boiler House Engineer and the Combustion Engineer will see that periodic samples of pulverization are taken from each mill, and notify maintenance foreman when wearing parts are to be replaced.

E. H. TENNEY,
11-11-26 Chief Engineer of Power Plants.

Instructions for Cahokia are somewhat similar although referring more definitely to specific equipment. Cahokia was first put in service in the fall of 1923 and

a cross section of the plant at that time is shown in Fig. 2.[2] The plant has been built in sections of eight 1801-hp. boilers, the first two sections being complete and the third section having 3 boilers in operation. The first two sections to which the instructions refer are fired from the bin system while the last three boilers are fired by unit mills.[3] It is interesting to note that although Cahokia is six years old it has remained one of the most interesting stations, due to changes and improvements which keep it always in the forefront of progressive plants.

Cahokia Is One of the Pioneer Pulverized Coal Plants

Original furnaces had refractory walls; some of these were later changed to water walls of various types, part refractories, bare tubes and covered tubes. Due to experience gained, they just carried out what is probably the most remarkable achievement in modern power plant construction, that is doubling the output of four of the original boilers and No. 1 turbine in the same space. A new turbine was installed but the old boilers with rebuilt furnaces are being used. Operating instructions for the central system follows; the Unit Mill instructions are similar to those for Ashley Street.

The operating code is as follows:

OPERATING INSTRUCTIONS
Cahokia Station
Pulv. Fuel Preparation Plant and Transport System, Union Electric Light & Power Co. of Illinois

1. Supervisors and workmen in the crushing, drying and pulverizing plant are expected to put forth every possible effort to operate this equipment in a safe manner and must observe all rules pertaining to the preparation and handling of pulverized coal.
2. Whenever any portion of the plant has been idle for a period of two days or more, all storage bins shall be thoroughly inspected before resuming operation.
3. All conveying and distributing piping must be inspected daily for leaks. Operators are cautioned against causing leaks in pipe lines or bins by hammering.
4. Do not open pulverized coal conveyors or other apparatus while running. Previous to opening, machinery shall be stopped and dust allowed to settle until safe for inspection. Repair work must not be allowed to start on any of the pulverizer equipment until thoroughly cleaned of all dust.
5. Do not open manhole or inspection openings in pulverized coal bins while fuel feed is being discharged into pulverized coal bins. Allow plenty of time for dust to settle.
6. All stationary lights shall be protected with dust-proof globes and wire guards. Only daylight or hand flashlights shall be used when inspecting the interior of coal storage bins, or pulverizing and conveying apparatus when in operation. When apparatus is not in operation, guarded drop lights with dust-proof globes, utilizing super-service portable cord may be used. Special dust-proof outlets and an adequate number of such cords shall be provided in the pulverizing plant.
7. Smoking and the use of open lights or torches are prohibited in the crushing, drying and pulverizing plant. The use of the burning or welding torch is not allowed except when repairs are essential when the Station Supervisor must be notified, whose duty it will be to see that such work is carried on in a safe manner, by either wetting down or placing a wet canvas around work where torch is to be used.
8. Before shutting down a mill, the dryers must be run empty. Gas inlet gate must be closed when dryer is running empty. Outlet gate must be left open until mill is shut down. If this is not possible mill must be vented into dryer dust outlet.
9. In case of dryer fire, shut off coal inlet from raw coal bunkers, gas inlet and outlet gate and use water as required. Shut mill down at once and do not start until it is ok'd by Mill Room Foreman.
10. Blow tanks must be closed tight at all times when not in operation by closing the dust-tight gate, flapper valve, shut-off valve, first valve off emergency line, first valve on short line, and both air operating cocks on panel board. Be sure to observe carefully that no pressure builds up in shooting tanks.
11. If it is necessary to admit air into the blow tank with a slight amount of coal still remaining in the tank (less than 2500 lb.), do not admit the air through the air jet piping, but through the 4-in. pipe provided at the top of the tank. Air jet is not to be used until skirt pipe has been raised and shot has been started.
12. When the blow tank is shut down for a period of longer than 24 hours, the tank shall be thoroughly inspected internally through the manhole to ascertain whether or not any fire or smouldering coal is in the tank. All blow tanks shall be taken out of service at least once a week and all accumulations of coal which cannot be removed by the regular transport system must be removed by hand.
13. Fire or hot coals must never be allowed to remain in dryer or coal spout and under no conditions allowed to enter mill. If coal is afire in spouts which feed mills, water quenching line is to be used. Pressure must be kept on this line at all times so that it is ready for immediate use.
14. Material reclaimed from Cindervane fan cyclones is to be run into raw coal bunker.
15. When work of any character is being done in the Station in a manner involving the possibility of explosion or fire hazard, it shall be the duty of any operator observing such dangerous practice immediately to cause such work to be stopped, reporting at once to the Mill Room Foreman, who in turn reports to the Station Supervisor, who shall investigate and give full clearance before work may proceed.
16. Explosion dampers on large mills are to be tried out once a week to see that they are in first class condition. Mill must be vented into coal dryer or dryer dust before starting.
17. Operators should not, under any circumstances, attempt to remove foreign matter from mill feeds while mill is in operation.
18. Gas inlet gates must be closed when raw coal bunkers are running empty and dryers are still full of coal.
19. Special attention must be given to the mill that has been changed over from the suction to the pressure type. CAUTION! Do not start mill or exhauster until dryer outlet gas gate, that is, the gate on the dryer side that the mill is vented to, is half way open or vented into gas outlet duct.
20. Care should be taken at all times to prevent the diffusion of coal dust in the atmosphere. Under no circumstance allow the accumulation of dust on beams or elsewhere.

E. H. TENNEY,
Chief Engineer of Power Plants.
Revised May 15, 1929.

By revising these instructions to meet specific requirements of different plants, a comprehensive and valuable guide for operating engineers and firemen can be made. Such instructions indicate to the men the important points to be careful of and will be of material assistance in preventing accidents, explosions and fires.

[2] For additional details, see Power Plant Engineering, April 1, 1924, page 365.
[3] For additional details, see Power Plant Engineering, June 1, 1928, page 600.

Improving Plant and Surroundings Proves Profitable

By D. C. Russell*

THREE YEARS AGO, the appearance of the Oakley, Kansas Municipal Light and Water Plant was as shown in Fig. 1. At that time, the power units consisted of a 200 and a 300-hp. Fairbanks, Morse semi-Diesel

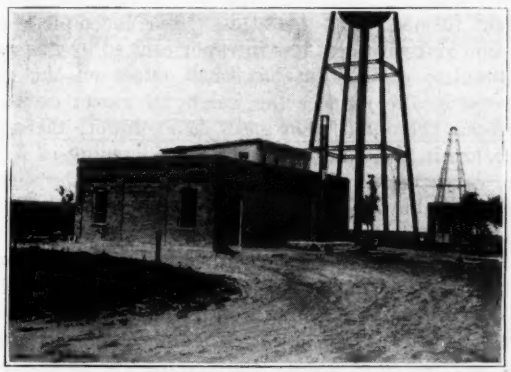


FIG. 1. PLANT GROUNDS IN 1926 BEFORE IMPROVEMENTS WERE BEGUN

engine. About this time, we started to rebuild the distribution system and I began to clean up the exterior as well as the interior of the plant.

Building construction is of common brick, the interior walls being plastered and the ceiling made of wood. The interior is now painted about once a year, the ceiling in ivory white with a 10-in. border of the same color around the walls, the upper part of the walls to the bottom of the windows, in light green and below the windows, in dark green. All interior paint has a hard glossy finish that may be washed easily, thus permitting it to be kept clean readily. Such paint absorbs no oil nor is it discolored by oil drops or spray. Occasional change in the color scheme adds to the pleasing effect produced.

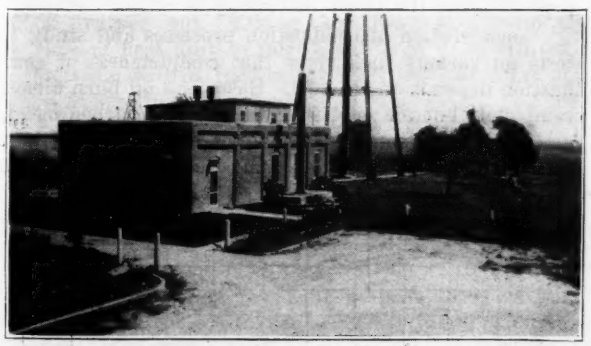


FIG. 2. PRESENT CONDITION WITH CURBING, WELL-KEPT LAWN, TREES, SHRUBS AND OUTLINE OF FLOWERING PLANTS

Blue grass and white clover were sown around the building during the spring of 1927. A year later, 25 Carolina and Norway poplar trees were planted and a rose hedge, not shown in the picture, was started along a fence. Tulips and other bulbs for early blooming and various annual flowers for later effect were also set out. Improvement accomplished at small expense by a little thought and effort, inspired by the enjoyment it returned, resulted in the present appearance shown in Fig. 2.

Pride in keeping up the appearance of the interior as well as of the exterior of the plant seems to have been carried over to the machinery itself and has resulted in good dividend returns. From the time of installation until July, 1926, several replacements and a vast amount of minor repairs were made. Since July, 1926, no such replacements have been made and other repair work has been reduced over 50 per cent. Better care and attention to the engines, brought about by increased interest in the work, thus actually reduced operating expenses.

Although the load has been increased over 30 per cent during the last 3 yr., there has been no engine failure and the 300-hp. engine ran 2 yr. without having any of its heads removed or pistons pulled. When the engine was overhauled, not one ring was found to be completely stuck, only three top rings being partially stuck on one side.

It is the belief of the writer that much stress should be put on appearance of plants and ground as this not only makes the daily task more pleasurable but actually results in better service and increased profits.

Electric light and power companies in the Greater New York area are to place overhead transmission and distribution lines underground during the next 10 yr. Property owners are welcoming this program of improvement because the removal of poles and lines not only improves the appearance of the streets but also enhances property values.

In 1929 $40,500,000 was spent in extending and improving the transmission and distribution lines of the five companies composing the system.

President Sloan states that the element of greatest value to consumers in the present program, is the changing over from a system of distribution known as radial to a newly developed network distribution which is being applied to all alternating-current service to yield the highest measure of continuity of service.

Most of Manhattan is served with direct current, which, for many years, has been distributed through a network system tying the blocks together like a checkerboard. The new alternating-current network system will be extended into this territory as rapidly as possible as well as in Brooklyn, Bronx, Queens and Yonkers. This system will form a grid of street mains, bound together block by block and tied in by means of transformers with generating station and distributing station feeders in such a way that, if an accident occurred to a street main or even to a transformer serving a whole block, the service to individual buildings would not be interrupted because current would come from transformers and mains in other blocks. For the most part, the new feeders to the network system will come directly from the generating stations, thus obviating the need and expense of additional substations.

Quadruple expansion steam engines were usually built for pressures of from 175 to 225 lb. per sq. in.

*Superintendent, Municipal Light and Power Co., Oakley, Kansas.

Pulverized Coal, Gas and Oil as Boiler Fuels

STUDY OF RELATIVE ECONOMY WHEN EACH IS BURNED UNDER BEST CONDITIONS. BY MARTIN FRISCH*

FOR OVER-ALL dollar economy of the plant, the cheapest fuel per heat unit may not prove the best. This must depend on a careful analysis of the final cost of steam making with such fuels as are available for the plant.

FUELS CONSIDERED

To cover fuels available in various sections, the fuels considered were Texas lignite, Illinois and Pittsburgh bituminous, Pocahontas, River anthracite, oil, and in gases, blast furnace, natural and coke oven. Two qualities of natural gas were considered, one with high CO and CO_2 and 30 per cent CH_4, the other being 97.5 per cent CH_4 and the rest nitrogen. Heat values, ash and moisture of the fuels were, as follows:

	Texas lignite	Illinois	Pitts-burgh	Poca-hontas	Anthra-cite
B.t.u. per lb.....	7000	11,700	13,400	14,500	12,450
Ash, per cent.....	10.0	10.0	8.5	5.0	14.0
Moisture, per cent	36.0	6.5	2.4	2.6	1.0

The oil considered had 84.3 per cent carbon, 12.7 per cent hydrogen and one per cent moisture, with a heat value of 18,600 B.t.u.

Furnace efficiency, heat absorption, gas temperature and draft loss depend on the character of the fuel, hence the influence of each fuel on performance of a given boiler was investigated, considering that the furnace and firing equipment in each case was the most suitable for that fuel and that all solid fuels were fired in pulverized form.

BOILER PERFORMANCE INDEX

Conclusions, checked against comparable boiler tests confirmed that the amount of sensible heat imparted to a pound of products of combustion is valuable as an index of boiler performance. This will vary with the heat value of the fuel, with the weight of gas and vapor formed, with heat loss from incomplete combustion and with heat loss in vapor carried by flue gases. Incomplete combustion has small effect on the index because it also reduces the weight of gases; excess air increases the quantity of gases, hence lowers the index; moisture in the fuel and vapor from burning of hydrogen vary the weight of gases and reduce the sensible heat available to heat them, hence have great effect on the index.

From the relation between available heat per pound of flue gas, the boiler exit temperature and the draft loss for various percentages of rating from 100 to 600 it was shown that, the greater the index, i.e., the sensible heat per pound of gases,—the greater will be the boiler output for a given draft loss. It was assumed that solid fuels had 20 per cent excess air or 15 per cent CO_2, oil had 15 per cent excess air or 13 per cent CO_2 and gases had 10 per cent excess air supplied. Under these conditions, boiler exit temperatures will vary with per cent of rating as shown in Fig. 1 for various fuels, and efficiencies as in Fig. 2.

LOSS VARIATION WITH FUEL

Preheating combustion air increases the sensible heat per pound of flue gas, hence its temperature and the rate of heat transmission to heating surfaces. The result is that, for a given per cent of boiler rating, draft loss will be less, efficiency greater and flue gas temperature less, the effect increasing as output increases.

Consideration of combustion processes and study of tests on various fuels show that completeness of combustion depends on the fuel. Gases and oil burn almost completely but for solid fuels higher fixed carbon means greater loss in the ash, especially for high rates of heat liberation per cubic foot of combustion space. At 20,000

*From a paper before the National Fuels Meeting of the A. S. M. E. at Philadelphia, Pa.

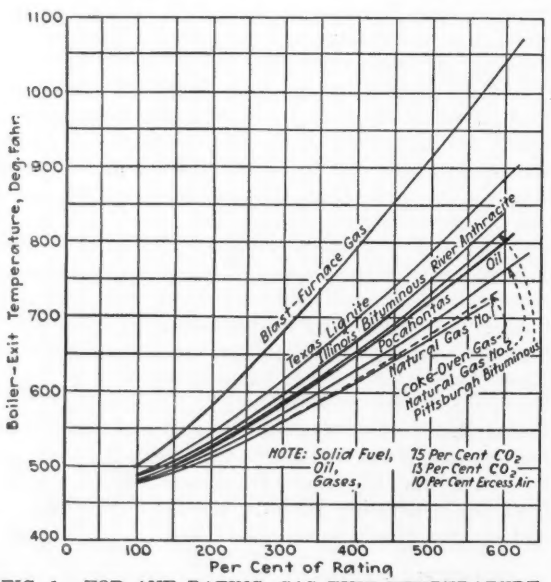


FIG. 1. FOR ANY RATING, GAS EXIT TEMPERATURE DEPENDS ON THE FUEL

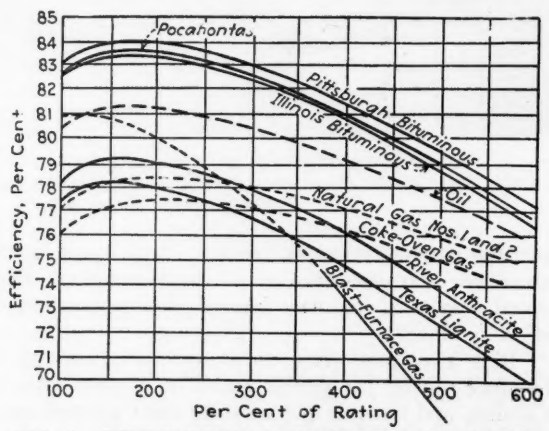


FIG. 2. EFFICIENCIES VARY WIDELY WITH THE FUEL USED

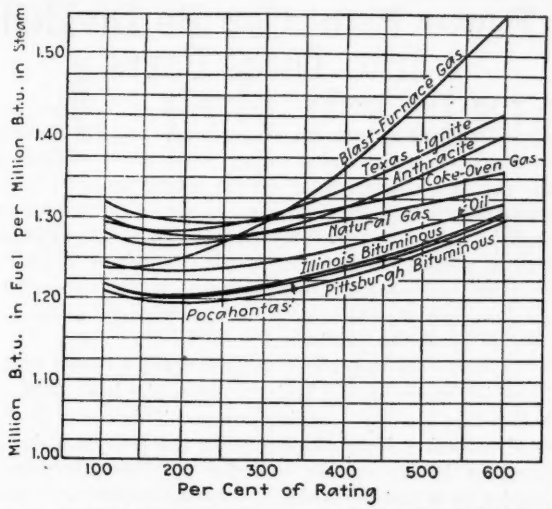


FIG. 3. RATIO OF FURNACE HEAT NEEDED TO HEAT IN STEAM VARIES WITH RATING AND FUEL

B.t.u. per cu. ft., this will run from ¼ of one per cent for lignite to 1.65 per cent for Pocahontas and 7.4 per cent for anthracite.

Radiation loss effect is practically the same for all fuels and was considered as three per cent at rating, 1.5 per cent at 200 per cent rating, one per cent at 300 per cent, 0.75 of one per cent at 400 per cent, 0.6 of one per cent at 500 per cent and 0.5 of one per cent at 600 per cent of rating.

Considering the heat balances for the various fuels, at 300 per cent of rating the losses due to incomplete combustion ran from 0.1 of one per cent for lignite up to 7 per cent for anthracite in proportion to fixed carbon; losses due to moisture and vapor run from 1.5 per cent for anthracite to 7 per cent for lignite varying about as moisture and hydrogen content of the fuel; oil and gases have no incomplete combustion loss but vapor losses for gases are as high as 10 per cent and for oil five per cent. Taking these losses into account, the ratio of heat units required in fuel to those utilized in the steam will be for various fuels and per cents of rating as shown in Fig. 3.

Factors of Plant Economy

This is not the whole story of plant economy for cost of plant to store and use each fuel and of operation enters in. To compare these, some definite conditions must be considered and a plant to furnish 1,000,000 lb. of steam per hour at peak load, having three boilers of 350,000 lb. per hr. capacity and a fourth for spare was taken. Air heaters and economizers were omitted for simplicity.

Cost for boiler plant exclusive of fuel and fan equipment will be the same for all fuels and was figured at $1,540,000, divided as follows: Boilers, superheaters, walls and settings, $580,000; meters and instruments, $20,000; feed pumps, $30,000; stacks, breechings and insulation, $150,000; foundations and structural, $500,000; wiring, $150,000; site development, $30,000; engineering, $80,000. For costs affected by the fuel used, the amounts are shown in Fig. 4, the values below the shading being a part of the fixed cost. Section 9 in each case is cost of draft equipment and fans; section 10 of fuels receiving storage and handling; section 11 of reserve-plant for peak-load auxiliary-power requirements of the boiler plant. Cost for fuel handling varies widely on account of difference in weights needed and in cost of pulverizing. Nearly twice as much lignite will be needed as of other coals, anthracite will require twice the pulverizing capacity of bituminous and oil requires costly storage tanks and pipe lines.

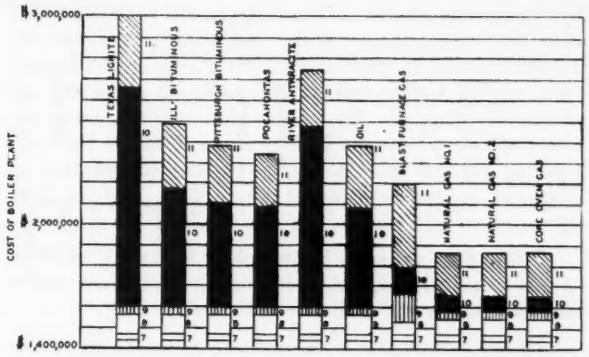


FIG. 4. VARYING COSTS FOR PLANTS TO USE DIFFERENT FUELS

From these costs of equipment, the yearly costs of making steam, exclusive of fuel costs have been computed. Fixed charges at 15 per cent on the cost which is common, will be $231,000 and operating charges on this part of the plant will be $159,000. Figure 5 shows the yearly steam making costs which vary with the fuel, the $400,000 below shading being part of the common cost. Section B is fixed charges at 15 per cent on fuel equipment and fans; C and D are operating charges on fuel and draft equipment respectively; E is fixed charges on draft equipment; F is fixed charges on values of 11, Fig. 4. The fixed and operating charges for various fuel equipment will vary because of differences in draft required and supplementary plant capacity needed. For instance, at higher percentages of rating, flue gases for blast furnace gas and draft loss in boiler and superheater will be more than double those for natural gas and nearly double those for bituminous coals.

At any given cost per 1,000,000 B.t.u. in the fuel, natural gas is the most economical fuel. Relative economy of making steam with any other fuel is shown

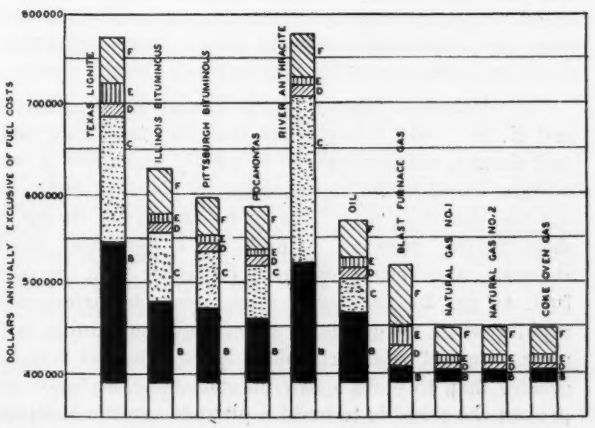


FIG. 5. YEARLY PLANT COST, ASIDE FROM FUEL COST, VARIES WITH THE FUEL

by the excess of cost of making steam with that fuel over that when using natural gas of the same cost per 1,000,000 B.t.u. in the fuel. These excess costs for various fuels at rating and at 500 per cent of rating are shown in Fig. 6. The price that can be paid per 1,000,000 B.t.u. for any fuel to make steam at the same cost as natural gas is shown by the intersection of diagonal constant-steam-cost lines with vertical lines of constant fuel cost.

While absolute costs in any plant will vary with size and conditions, the relative costs for various fuels under best conditions for each are indicated by Fig. 6.

Further elaborate analysis was given to show the cost of using one fuel in a plant designed for another, taking into account overhead and operating cost for essential changes in the plant. The conclusion was that a plant designed for any solid fuel will be most economical when handling that or a higher grade fuel which does not involve capital expenditures, if the higher

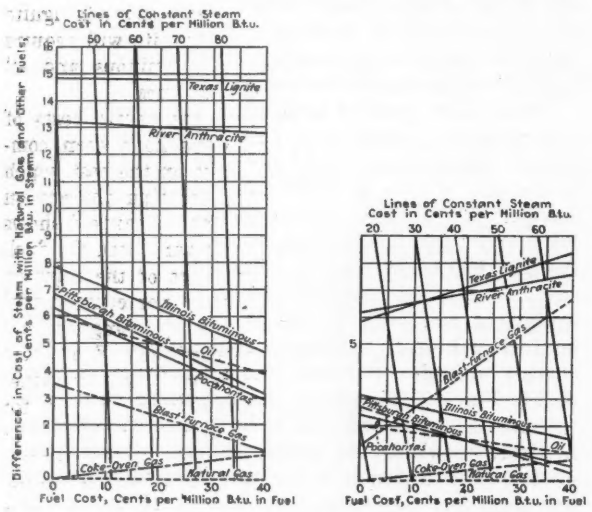


FIG. 6. COMPARISON OF STEAM COSTS WITH VARIOUS FUELS

grade is obtainable at the same cost per 1,000,000 B.t.u. in the fuel. A plant for high grade fuel cannot usually develop capacity with a lower grade. Pulverized fuels can generally compete with oil or gas except where gas or oil prices are very low. Low grade solid fuels are generally economical locally in places where high-grade fuels are handicapped by high mine or freight charges.

In discussion, Messrs. S. B. Flagg, E. W. Harris and K. M. Irwin brought out that in considering any fuel change, the permanence of supply and price is important as otherwise the changes in plant in order to use the new fuel may have to be amortized during a short period, running as high as 30 per cent fixed charges. Also repair costs may be higher with the new fuel, as for instance steel stacks seem to deteriorate rapidly when using oils or other fuels containing sulphur. Cost of altering a plant for a new fuel may be greater than to build a new plant to use that fuel. At present the trend is to build a plant to use the cheapest fuel that is available.

Power Plant Can Be Divided Into Three Parts

MODERN POWER PLANTS convert fuel into electric power through an intermediate agent water or steam, the conversion being made more efficient by the use of a second water system acting more or less in an auxiliary capacity. The operation of the station can then be considered in three parts. First: a continuous stream of fuel, usually coal, which is received by boat or railroad, unloaded, crushed, elevated to bunkers and fed into the boilers where it is burned, giving up the heat of combustion to the boiler.

Second: the steam and water system, a closed system in which water in the boiler absorbs the heat from the boiler furnace, thus making steam. This steam is then used to make electrical energy in the generator by expanding in an engine cylinder or through suitable nozzles in a turbine which drives the generator. After leaving the turbine, it exhausts into a condenser where it is condensed into water to be fed back to the boiler.

Third: the stream of water which is circulated through the condenser to absorb most of the latent heat of the steam and convert it back to water. Roughly, a pound of good coal will make 10 lb. of steam with a heat content of somewhere around 1300 B.t.u. per lb. for a modern plant. Of this 1300 B.t.u., approximately 1000 B.t.u. are carried away in the condensing water leaving about 300 B.t.u. available for running the auxiliaries and generating electricity.

Thus, out of a total of 13,000 B.t.u. in a pound of coal, only about 3000 B.t.u. goes into useful work. This gives an efficiency of about 23 per cent. The best stations will reach an efficiency of around 27 per cent, while older ones will run considerably less.

Condensing water is not absolutely necessary but it does two things which makes it advisable. First: it makes it possible, by the expenditure of a comparatively small amount of power, to almost double the thermal efficiency of the turbine and, second, it allows the steam to be condensed and used over again for feedwater. This condensed steam is pure and eliminates boiler scale. If condensers were not used, the exhaust, beyond possible process or feedwater heating needs, would have to be released to the atmosphere and fresh water used in the boilers.

EL PASO ELECTRIC CO., El Paso, Texas, subsidiary of Engineers' Public Service Co., Boston, Mass., operated by Stone & Webster, Inc., Boston, has completed the first unit of a new steam-operated electric generating plant, to be known as the Rio Grande Station, and will place it in service at once. The plant was begun early last year, and has a rated capacity of 25,000 kw.; other units of approximately like output will be built at an early date. The station will use natural gas as fuel; this is piped from the gas fields in the southwestern part of New Mexico and an adequate supply of condensing water is procured from the Rio Grande irrigation system. The completed unit will be used largely for industrial power service, notably for the new electrolytic copper refining plant of the Nichols Copper Co., New York, which is now nearing completion, and for which the El Paso company has contracted to furnish complete power requirements.

Upkeep of Piping Systems

METHODS OF AVOIDING AND CORRECTING TROUBLES OCCURRING IN PIPING, FITTINGS AND VALVES. FACTORS WHICH CONTROL AMOUNT OF MAINTENANCE REQUIRED

FUNDAMENTAL requirements of a piping system include reliability, accessibility and durability. In order to fulfill all these requirements, the system must be correctly designed, properly installed and adequately maintained. A major consideration in the design of a system is that it be so laid out as to permit making repairs without interfering with the regular service of the plant. It is not reasonable to expect an operating man to take much interest in his station work if he is required, frequently, to work nights in order to keep his plant in good working condition. Wherever possible, therefore, the plant should be so designed that repairs and replacements can be made during spare time on a regular shift.

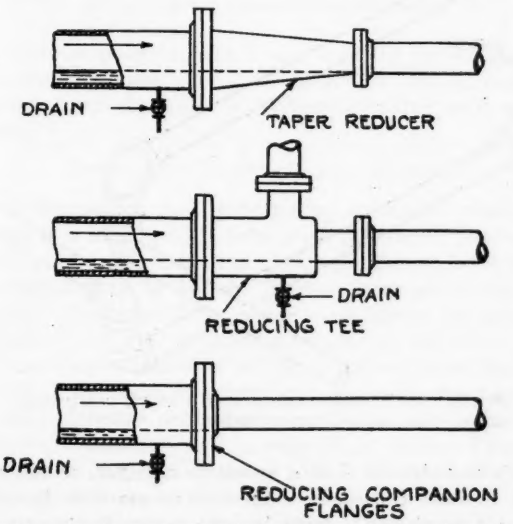


FIG. 1. PROPER LOCATION OF DRAINS AT REDUCING FITTINGS

FACTORS CONTROLLING REQUIRED MAINTENANCE

Among the factors which affect the amount of maintenance that will be required by a piping system are provision for drainage of water, relief of entrapped air, expansion and contraction due to changes in temperature and method of supporting or anchoring pipe in order to lessen vibration. Hence the manner of installation is a highly important item in the ultimate maintenance cost. Pipe systems should be so designed as to need a minimum of drains and these should all be automatic. It is best to run each drip independently to its own free outlet or trap or run them independently to a large receiving tank which must be effectively drained by a trap or other means. Wherever traps are used for drains, they should be inspected regularly to see that they are operative.

Many accidents occurring to engines are due to poorly constructed exhaust and drip pipes. Leakage due to opening up of steam pipe joints caused by water hammer may also be charged to lack of proper drainage. In high-pressure piping, water is dangerous. If carried into the engine cylinders in considerable quantities, it is liable to wreck the engine, or at least rupture the cylinder heads. Condensation in the mains is likely to produce water hammer, which in turn causes vibration and tends to loosen the joints. Proper location of drains for different conditions of pipe reduction is illustrated in Fig. 1 and a simple form of drip receiver in Fig. 2.

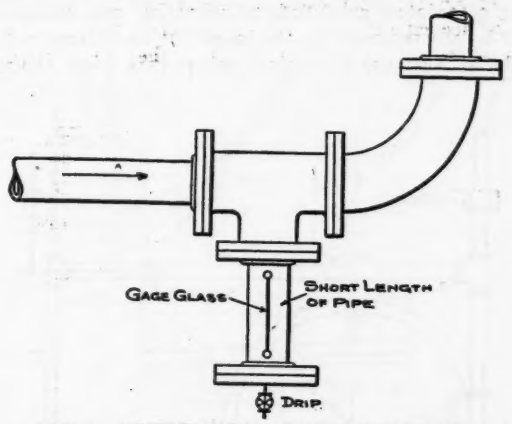


FIG. 2. SIMPLE FORM OF DRIP RECEIVER

POCKETS IN PIPE LINES SHOULD BE AVOIDED

Pockets in piping should be avoided but if this is not possible, efficient means of draining these pockets should be provided. Drop legs, reservoirs or, preferably, a combination of either a drop leg or reservoir in the main header, with a separator above the throttle form good drainage for steam engine piping. These drains should be connected with efficient steam traps; valves cracked open should never be used for this purpose. Pockets may be formed in a pipe line due to settling of supports or sagging of the line, after installation, therefore pipe lines should be checked occasionally for alinement.

Steam heating mains should pitch down and away from the boiler and return mains down and toward the boiler so that the water and steam move through the pipes in the same direction in each case, thus preventing noise in the system.

Pipe Anchoring Methods

Pipes are anchored not only to insure permanency of position and to prevent undue strain upon a header or

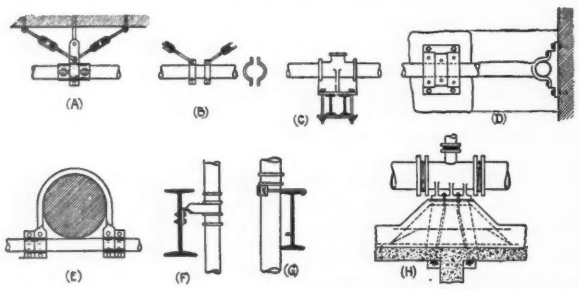


FIG. 3. TYPES OF ANCHORING FOR PIPES: A AND B, SUSPENSION ANCHORS; C, ANCHOR TEE; D, WALL SUPPORT AND ANCHOR; E, COLUMN ANCHOR; F AND G, ANCHORS TO RISERS; H, ANCHOR TO HORIZONTAL BEAM

engine frame but also to prevent or lessen vibration. Various forms of anchors are illustrated in Fig. 3. The anchor to prevent vibration should be placed at the point of greatest amplitude of vibration and should always be accompanied by the introduction of long radius bends at any nearby points where the pipe changes

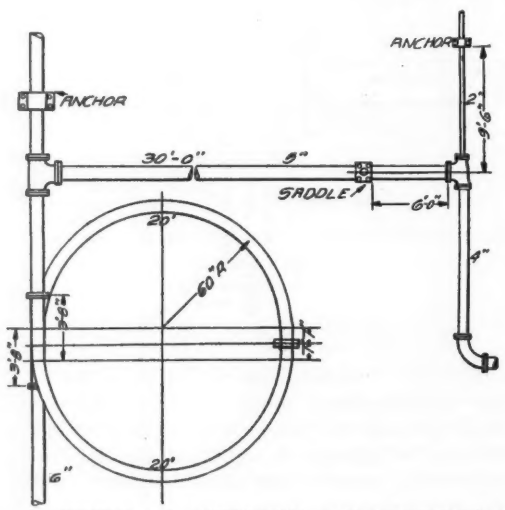


FIG. 4. METHOD OF ANCHORING AND PROVIDING FOR BRANCH EXPANSION

direction or expansion joints and by the installation of a receiver of large volume at the end of the pipe run. Allowance should also be made for expansion of cross branches so that there will be sufficient length to take up the expansion by the spring of the pipe as shown in Fig. 4.

Provision for expansion and contraction due to heating and cooling of a pipe line may be provided in a simple manner as illustrated in Fig. 5. This arrangement may be installed in places where necessity for such allowance has developed after the original installation or expansion joints, many types of which are now in the market, may be used.

Entrained Air Causes Corrosion

Maintenance of piping involves means to avoid or reduce deterioration and means of maintaining proper operating efficiency of the pipe for the purpose for which it is intended. Under bad conditions, pipe will not last over 2 yr. while, under the best conditions, it will last 20 yr. Besides chemical action due to special conditions of the water or steam in the pipe, the greatest factor in pipe corrosion is entrained air. Hot water is much more active than cold water in corroding pipe. Water that has picked up a surplus of air is very destructive and should be eliminated by venting or by deaeration. Corrosion of pipe exterior may be prevented or, at least reduced, by painting with a reliable protective paint.

Loss of efficiency may be due to leakage of pipe

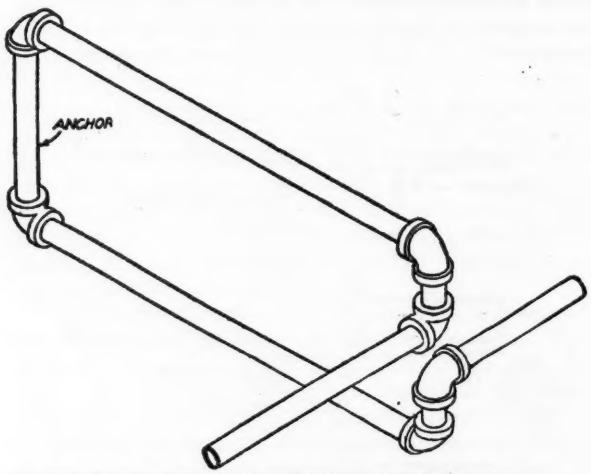


FIG. 5. EXPANSION BEND MADE WITH SCREWED FITTINGS

joints or valves or due to excessive radiation or absorption of heat caused by improper or more or less destroyed insulation. Joint leakage occurs frequently in factory pipe systems. In one case, a maintenance engineer noticed from his records that almost as much steam was being used in the factory at night, when it was not operating, as during the day. Investigation disclosed many leaky valves and joints and many cases in which steam valves attached to heaters were left open all night. Loss of this steam increased the demand upon the boilers which, being automatically controlled, supplied this demand instead of operating very lightly as they should have done normally. But an adequate record system with recording gages and a proper analysis of these records led to large reduction in steam cost.

Pipe Leakage Repair

Pipe leaks are best taken care of by replacement. Circumstances, however, do not always permit this to be done, in which case temporary repairs should be made. Small pin holes can be repaired by drilling out the defective part with a twist drill, tapping out the holes and screwing in closely-fitting threaded plugs of soft steel or wrought iron and riveting over the ends If the leak is extensive, however, it will be necessary to

use a pipe clamp. A split suction pipe may be temporarily repaired by covering the split part with a piece of sheet metal, preferably sheet lead, bent to the curvature of the pipe and put on with red-lead putty. Canvas should be wrapped around this and the entire patch held with bands.

Where pipe systems cover a large area such as in large heating system or industrial uses, it is best to divide the system into sections. This permits not only of more convenient inspection and replacement of parts but reduces to a minimum long or troublesome horizontal branches. In this case, independent risers are located where they supply the largest number of radiators or heaters and horizontal branches are made

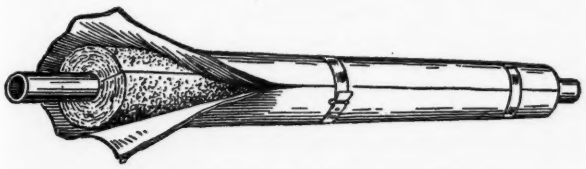


FIG. 6. SECTIONAL PIPE COVERING

as short as possible. Each section of the system should be made independent of all others so that it can be closed down for repairs without affecting any other part.

Insulation Materials and Methods

Condensation in a large piping system is enormous, hence it is important to have pipes thoroughly protected with a good nonconducting covering. Materials for pipe insulation may be had in various forms and compositions. "Sectional" or molded insulation is usually wrapped in canvas or asbestos paper and held by means of bands such as shown in Fig. 6; plastic insulation is mixed in the form of mortar and applied to the pipe in layers. Asbestos paper for this purpose may be had in varying thicknesses and in rolls 36 in. wide. Fittings and valves may be insulated with a plastic coating or with molded covers made in sections to fit them. The gain secured by use of insulation is shown in Fig. 7. Importance of prompt repair of insulation is due not only to the heat savings accomplished but also to the rapidity with which such insulation is destroyed at the edges after a break has been made.

Pipe-Line Leakage May Shut Down Machinery

Destructive leakage may occur into a pipe system as well as from it. In a factory in which a metal-washing machine was used which was heated by steam coils, frequent clogging up of a centrifugal pump, connected to the system, was experienced. At the same time, the operator of the metal washer complained that chemical compound had to be added too frequently to the washing solution. Investigation by the maintenance engineer revealed a crack in the steam coil which permitted the washing compound and deposit to be sucked into the pump, requiring the use of hydrochloric or muriatic acid in order to clean it out.

Clean, sharp threads form the best means of obtaining tight screwed joints. It is essential, therefore, that care be used when handling the pipe to keep wrenches and tools off the threads and to protect them from injury in other ways.

For most purposes, flake graphite and oil, preferably cylinder oil, is one of the best dopes, as joints made with it can be taken apart easily. A mixture which is suitable for either steam or water pipes is composed of 10 lb. of fully ground yellow ochre; 4 lb. of ground litharge; 4 lb. of whiting and ½ lb. of finely cut hemp. This is mixed with linseed oil until it is about the consistency of putty. White lead and red lead are also used. For permanent joints, red lead is satisfactory. A mixture for ammonia pipe joints is composed of litharge and glycerine mixed in small quantities for each joint. As this substance sets quickly, a joint made with it should not be changed.

Pipe dopes are used with two different ideas in mind. Some use them to fill the joint and make it tight; others use a lubricant of heavy base which enables them to pull up the joint much tighter with the same effort. The first method is satisfactory if the pipe is not to be taken down; the second method is usually the better of the two as it permits dismantling without difficulty.

Flanged Connections

Above 125-lb. pressure, flanged fittings should be used. Among the flanged types are (a) screwed and faced, (b) screwed and peened, (c) rolled, (d) lapped and (e) welded, the latter two being the most popular

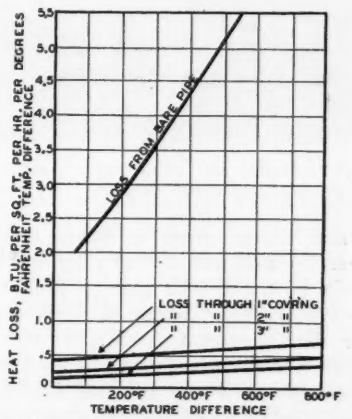


FIG. 7. HEAT LOSSES FROM 3-IN. PIPE WITH 85 PER CENT MAGNESIA COVERING

at present in high-pressure service. Welding must be done by expert, experienced welders in order to be reliable. Many materials are used for gaskets depending upon the pressure and nature of the fluid. With good true surfaces, whose planes are parallel, thin packing may be used but if the packing is pliable and narrow in comparison to its diameter, there is a tendency to buckle or bend inward as it is being tightened in a horizontal pipe line. In such cases, it may soon blow out or leak and it is better to use a wire inserted or corrugated gasket. Corrugated steel makes a gasket suitable for superheated steam.

Asbestos packing may be used for acids, ammonia or oils. When rubber gaskets are used, they may be prevented from sticking if the flanges are treated with plumbago, pulverized soapstone or chalk. When this is done, the joint may be broken and the gasket removed whole and used over again. In fitting a gasket, the

hole through the gasket should be slightly larger in diameter than the pipe, as some kinds of gaskets spread when tightened or after use and so decrease the size of the opening. Gaskets of rubber or asbestos may be cut by placing the sheet on the flange and striking around the edges and holes with a ball-peen hammer.

Care of Valves

Valves should never be permitted to leak. Leaking results in unequal wear on the disc. This applies particularly to those valves which are normally closed or which remain closed over considerable periods of time. The most conspicuous cases of this are the blowoff valve and the safety valve which probably require more attention than any other valves in the power plant.

Corrosion in valve parts, especially of valve disc and seat, may usually be prevented by proper choice of metals. Sticking of valves may result from corrosion

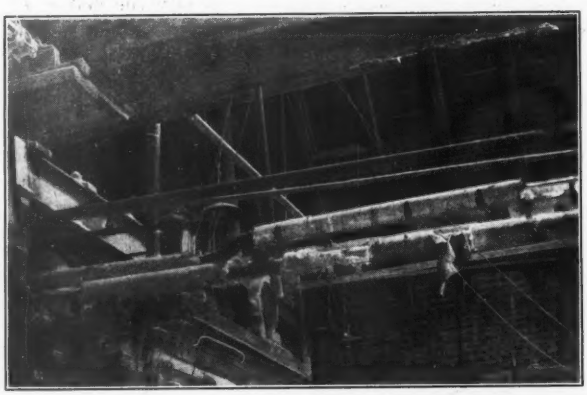


FIG. 8. MAINTENANCE OF THIS TYPE ASSURES COSTLY OPERATION

or incrustation which causes a cement action to take place between the disc and seat or plug and stem. This is more likely to occur with gate or plug valves than with any other types. Cutting of discs and seats by moisture or dirt in steam is usually due to partial opening. Gate valves should never be used where throttling is necessary; they may cut and clatter. Sticking may be due to tight screwing up of stem packing, especially if the packing is worn.

Leaky valves should be repaired as soon as possible after the leak is discovered. Leaks in valves may be due to distortion of the valve seat caused by the weight of piping carried by the valve. Sometimes leakage is due to distortion of the valve body caused by serious strain set up when a valve is improperly forced into a pipe line. In installing a valve, the wrench should always be applied to the end at which the threaded connection is being made. All valves should be operated slowly and no wrench or bar should be applied to hand wheels. If a valve cannot be turned in the ordinary manner, it is likely that dirt is jammed on the seat or that the packing needs renewing.

Packing and Regrinding Valves

Valve packing should be inspected frequently. If leaky packing cannot be made tight by a moderate amount of screwing up, it should be renewed at once. The need for renewal of packing is not always indicated by leaking, but the position of the packing nut or packing sleeve will often indicate this need. It is best to follow the advice of the manufacturer in the choice of material for packing.

Valves with generous packing space, especially as to depth, should be chosen. Under this condition, tightness may be secured under moderate pressure. Nuts on packing studs should be tightened evenly to avoid binding on the stem. For valves which stand full open much of the time, the packless type is to be recommended. If the service is of such character that regrinding is likely to be necessary, "regrinding" valves should be specified.

Safety valves should be raised from their seats every day to make sure they do not stick from any cause and the steam gage should be observed to see if the valve blows off at the pressure for which it is set.

Before installing a valve in a pipe line, it should be examined to see whether the direction of flow marked on the outside of the body is correct. In one case where a needle valve had been installed on an expansion tank of a heating system, it was observed that the expansion tank was continuously full, hence was not functioning properly. Inspection of the valve showed that it had been installed backward notwithstanding the arrow cast in the body indicated correct installation. In its incorrect position, the valve leaked and permitted the tank to fill up.

In all maintenance work, it is important that preventive rather than corrective methods be emphasized and that inspection be regular and ample and replacement prompt.

Shooting Baffles for Boilers

By William E. Smith*

STACK TEMPERATURES averaging 600 deg. F. clearly showed a leaky condition of the baffles in our 250-hp. Edge Moor boilers.

On examining these tile baffles, which had been in service for some years, we found that an entire new baffle job was necessary for both front and rear.

Our estimate for replacing tile baffles in three of these boilers amounted to $1200 but we thought we could beat this figure by building monolithic baffles with our own boiler room crew, as we had a refractory gun originally ordered on trial for furnace wall and arch repairs and patches. It worked out so successfully in this capacity that we thought we could build baffles with it by using a wood lattice form and shooting a plastic mixture directly against the form.

We called in H. M. Miller, the service engineer of the Quigley Furnace Specialties, which manufactured the gun. He told us that the plan was feasible and demonstrated the gun for this purpose on the first monolithic baffle built.

Procedure was as follows: Wood 2 by 4-in. stringers were laid across the tubes to support the lattice work of 1 by 1⅝-in. slats, which were placed diagonally down each lane between the tubes, with crossed diagonal slats down each lane from the opposite direction. These slats were fastened to the stringers across the top and beneath the bank of tubes. In this manner, we built the forms

*Chief Engineer, Essex Rubber Co., Trenton, N. J.

for front and rear baffles of three of the boilers, six baffles in all, as in Fig. 2.

Material required for the six baffles was as follows: Dry refractory material, 4200 lb.; high-temperature cement, 3200 lb.; Portland cement, 1 bag.

First the high-temperature cement was diluted with water, bringing it to the consistency of a creamy batter; then we added the dry refractory material a little at a time, mixing it all thoroughly. When about ready to apply the mixture with the refractory gun, we added a small amount of Portland cement to aid the initial set.

FIG. 1. GUN OPERATOR REGULATES CONTROL VALVES FOR COMPRESSED AIR AND PLASTIC MIXTURE AS USED FOR PLACING BAFFLES AND FOR PATCHING DOOR ARCHES

This plastic mixture was made in several batches so that the material would be always in a sufficiently moist condition. The nature of the mixture was somewhat stiffer than mortar and handled nicely when applying it with the gun.

Methods of Application

Commencing at the bridge wall, we shot the mixture from the gun against the lattice work, using at first a

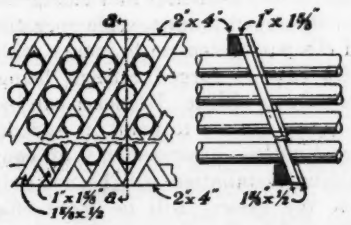


FIG. 2. LATTICE WORK WAS ARRANGED AMONG TUBES AND SERVED AS A FORM ON WHICH PLASTIC MATERIAL WAS BUILT UP

short nozzle, which, as the work progressed, was extended with sections of ¾-in. pipe.

After applying the material, we tamped it with a special tool made of ½-in. pipe. With this tool we could not only tamp and smooth the surfaces of the baffles but, by turning it on edge, we worked the material snugly in around the tubes.

We built the baffle to full thickness in several applications, alternating between front and rear baffles, giving each successive layer an opportunity to dry out slightly and set before applying the next layer, until a thickness of 4 in. was reached. Soon after the baffles were completed, a slow fire was started to dry them out and about 8 hr. later the boiler was raised to the steaming temperature. The wooden lattices were left in place and allowed to burn away.

The speed of application was surprising and we made a good job at a low cost.

Our own figures on the cost of front and rear baffles for three boilers were as follows:

7400 lb. refractory mixture	$226.70
1 bag of Portland cement @ 70c	.70
200 ft. of lumber @ $12.00 per C	24.00
55 hr. labor @ $1.00	55.00
55 hr. labor @ 62c	34.10
Total for 6 baffles	$340.50

The difference between this and the estimate on tile baffles was a quite satisfactory saving. As now installed,

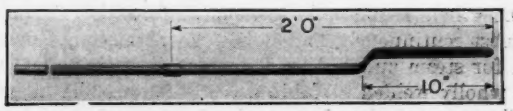


FIG. 3. SMOOTHING AND PACKING AROUND TUBES WAS DONE WITH THIS TAMPING TOOL

the new monolithic baffles are gas tight and enable us to operate on an average of 135 per cent of rating over 24 hr. with peaks as high as 180 per cent in these hand fired boilers. Our average stack temperature is down to 495 deg. F. at this rating with 560 deg. at the peaks, which indicates a good, tight baffling job that has effected a considerable saving of fuel.

Correction—Heating Value of Wood

On page 5 of the January 1, 1930 issue of Power Plant Engineering, the heating values given for various woods are incorrect. In transcribing from the original table, the wrong column was copied so that the figures given are the equivalent weight of coal of 13,500 B.t.u. In the following table are given the correct heating values of air-dried woods in B.t.u. per pound and, to make your copy correct, these values should be substituted for those given on page 5 of the January 1 issue.

Wood (Air Dried)	Heating Values B.t.u. per pound
Ash	5450
Beech	5400
Birch	5580
Cherry	5420
Chestnut	5400
Elm	5400
Hemlock	6410
Hickory	5400
Maple, hard	5460
Oak, live	5460
Oak, white	5400
Oak, red	5460
Pine, white	6830
Pine, yellow	6660
Poplar	6660
Spruce	6830
Walnut	5460
Willow	6830

Welding for Boilers, Pressure Vessels and Steam Lines*

PRESENT STATUS OF ALLOWED CONSTRUCTION AND METHODS. BY C. W. OBERT**

OF THE MARKED change in the position held by fusion welding for boilers, pressure vessels and piping, part is due to advance in public opinion and part, probably the underlying cause, to improvements in processes and practice.

In 19 states and 15 cities, the A. S. M. E. boiler code controls, while Massachusetts, whose law antedates the code by five years, has its own standards. Outside these areas, no restrictions exist on boiler construction or operation.

In the first code of 1914, welding was not considered, as data were insufficient to permit formulation of rules. Since then requests have come before the Committee almost continuously and now, for pressures not over 15 lb. for steam and 160 lb. for water, heating boilers may be wholly welded. Welding is also admissible in power boiler construction for certain details such as joints in boiler furnaces of staybolted and self-supporting type which are subject to compression only, also seal welding of tube ends in fire-tube and locomotive boilers, attachment of inserted nozzles, threaded outlets, brackets, supports and other fastenings for the connection and support of piping and structural details. Recent revision of the Code permits welding of turned in flanges and of rings formed of steel plate for firedoor and similar openings, also of flanged-in edges of water legs. Progress is being made and it seems probable that before long something will be heard about large scale developments in boiler welding.

WELDED BOILER DRUMS

Of influence in the favorable attitude toward welding of boiler drums is the growing opinion that, if such drums could be welded throughout so as to eliminate microscopic cracks and seams likely to exist in riveted joints, tendency toward concentration of caustic salts therein and consequent embrittlement of the plate would be eliminated. No attempt has as yet been made to experiment with this application of welding under proper working conditions but it is being considered in a number of plants where plate cracking trouble has been experienced. If loss of riveted drums from embrittlement should continue as it has during the past few years, experimental installations of all-welded drums for water-tube boilers will quite certainly be heard of.

Massachusetts gives little credit to welded construction except for low-pressure heating boilers and even those must have riveted longitudinal joints.

In Canada, all provinces allow welded low-pressure heating boilers and the Conference of Canadian Chief Inspectors, coöperating actively with the Boiler Code Committee, has accepted welded details as previously given. Ontario has signified its willingness to accept welded boiler drums for high pressures, if process and construction methods meet the approval of the inspection department.

For unfired pressure vessels, the Code has extended its original allowance of 20 in. diameter, length not over three times diameter, working pressure 100 lb., plates not over 5/8 in. thick and unit stress not over 5600 lb. per sq. in. so that, where the Recommended Procedure is followed, diameters up to 60 in. are permitted, pressures to 200 lb., unit working stress to 8000 lb. for double V longitudinal welds, to 6500 lb. for butt single V girth or head welds, 7000 lb. for double full-fillet lap or girth welds and 5600 lb. for spot or intermittent girth or head welds. This follows the lead of the California Department which has had such rules in force since 1926. Unless, however, Recommended Procedure is followed, the original limitations stand.

Ohio put the new Code rules into effect on Jan. 1, 1930, Oregon is taking steps to do likewise, also Seattle and Detroit are talking of similar moves. New Jersey favors the revision while New York and Pennsylvania are studying the question.

Massachusetts has no provision for welded pressure tank construction while Canadian provinces codes are mostly silent as to welding for pressure vessels; British Columbia has, however, adopted the revised Code in full and Ontario accepts welded construction for all sizes and pressures, if process and construction are approved by its inspection department.

WELDS FOR PIPING

Piping for heating and power plants has shown greater advance in fusion welding than boilers or pressure vessels, due, perhaps, to the general absence of legal restrictions as to such construction. Designing and construction forces have been able to use their best judgment as to fabrication of piping, valves and fittings to secure greatest durability and freedom from trouble.

Large industrial plants that maintain both piping and welding gangs have found the welders under emergency conditions able to handle erection or repair work in a safe and dependable manner in a fraction of the time needed for the ordinary threaded or flanged fittings methods. From experimental and emergency attempts, welding has developed to large scale operations, forming of tees and ells with eccentric branches, which would be difficult with cast or forged fittings, being effectively done and extremely simple. Branches can be taken from a main at top or bottom to point in any desired direction, giving limitless arrangements of connections, so that the piping installation will be not only more economical but the system will be more efficient, drain more readily and be free from pockets and air binding.

From low pressure and vacuum lines requiring tightness but little strength, welding has advanced to high pressures without limit provided special precautions, including annealing of welds, are adhered to for pressures over 300 lb. It is customary to subject connections to hydrostatic head of about 2½ times working pressure up to 600 lb., 2.2 times for 900 lb. and 1350 lb.

Heating and piping contractors have taken up the fusion method and a manual of standards for welded piping construction is in preparation which is expected to do much to develop and standardize safe and satisfactory practices, from low pressures up to 270 lb. Expansion of the use of the cutting torch, now employed

*Abstracted from a paper presented before the International Acetylene Assn., at the Chicago meeting, November, 1929.

**Union Carbide & Carbon Research Laboratories, Long Island City, N. Y.

to cut large pipes to length, so as to join pipes seems a logical step.

As to welded piping codes, Michigan formulated such a code in 1925, administered under the Department of Labor and Industry. In Ohio, the Industrial Commission is now formulating a complete piping code for steam, hydraulic, pneumatic and refrigerating systems with definite provisions for welding, probably to be made effective early in 1930.

Canada, Ontario and British Columbia, it is understood, require inspection of piping systems and welding is provided for, although definite codes have not been established.

Portable Diesel Engine Plant

360-Hp. Diesel Engine on Standard Flat Car Supplies Portable Power for Great Northern Railway

WHEN the Cascade tunnel was finished in the spring of 1928, a portion of the equipment used on the job, including five 360-hp. Fairbanks-Morse Diesel engines, was turned over to the Great Northern Railway by the contractors and these units are now being used at various points on the systems where additional power is required.

Unique mounting makes one installation of special interest. The Great Northern supplies gravel for its road beds from various pits at points on the company's right of way. These gravel deposits vary in size, the time required to exhaust one deposit varying from a few weeks, to several months or a year. All of the equipment is of a semi-portable nature so that movement from one location to another is readily accomplished.

To supply the power required, W. R. Wood, mechanical engineer for the Great Northern System, devised the application illustrated. One of the 360-hp. Diesels, a six-cylinder, 14 by 17-in., 257-r.p.m. unit, was mounted on a specially-constructed, standard size flat car and partially housed in. Longitudinal girders on the car are of size to support rigidly the weight of the engine and generator and are so spaced as to accommodate the flywheel without weakening the structure.

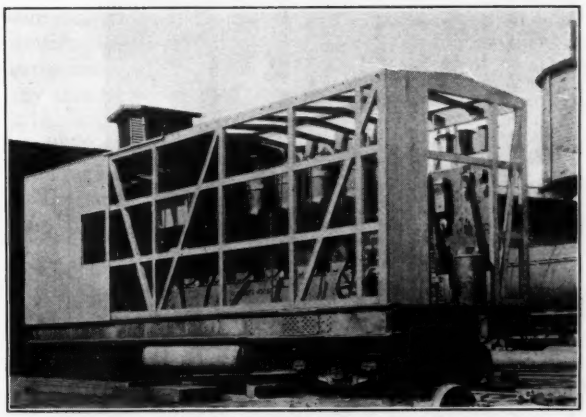
Cross bracing has been built in to eliminate, as far as possible, any tendency on the part of the framework to weave when the engine is in operation. The engine is direct connected to a 3-phase, 60-cycle, 2300-v. generator, excitation for the field being supplied by a 12½-kw. exciter. Because of the small lateral space available, the exciter is mounted rather close to the engine shaft and the Flex-Mor drive is employed.

As the installation was designed for semi-portable service and because water supply is unfailing at all gravel pits, no special cooling water system is provided, the local sources of free water being used for engine cooling. Varying composition of the water encountered makes it necessary to keep a careful check on scale formation within the water jackets. The car carries an underslung tank of approximately 1500-gal. capacity for the storage of fuel oil, an amount which should keep the engine running at full load for more than a week.

Auxiliary equipment includes a 3¾ by 4-in. air compressor direct connected to a 3-hp. engine to supply air at 250 lb. to three air bottles for main engine starting purposes. Fuel and lubricating oil pumps are built in as engine auxiliaries. Complete without fuel, total weight of the plant is 138,600 lb.

In operation, the plant is blocked up off the tracks to give additional rigidity to the car frame but no provision is made for anchoring the car itself to the tracks, as the operation of the engine is sufficiently smooth to make this precaution unnecessary.

Since the gravel plants mentioned are worked only during the summer months, the power plant is available for use at other points during the winter, to meet the increase of certain power requirements where equipment is used during the winter. The plant is also designed to supply power in cases of emergency due to breakdowns at any point on the company's system, so that it is expected that it will be in actual service almost continuously.



FAIRBANKS-MORSE SIX-CYLINDER DIESEL ENGINE INSTALLED ON FLAT CAR FOR PORTABLE SERVICE

Two general types of units are used in engineering and scientific work: The fundamental physical units fixed by arbitrary preserved standards and derived physical units defined in terms of the fundamental units and of which no standard need be preserved.

Thus, by the former, the unit of length is preserved as a platinum bar in Paris, the unit of mass is preserved by a piece of platinum in Paris and the second, the unit of time, is preserved in the constancy of the speed of rotation of the earth. Similarly, the standard candle is preserved or fixed by an arbitrary standard and the degree Centigrade or Fahrenheit fixed by the constant difference between freezing and boiling water at sea level.

Of the derived units, the unit of area is the area of a square of which each side is a unit of length, i.e., L^2, so that there is no need of preserving a standard of area. The unit of velocity is defined as the distance per unit of time or $D \div T$. It would be impractical to preserve such a standard.

Quantities, such as area, volume, velocity and electric current, may be defined in terms of fundamental quantities of length, time and mass. Choice of these fundamental units was governed by practical consideration of the ease of preserving material standards and their susceptibility to accurate measurement.

ELECTRICAL PROTECTION *of* LARGE TRANSFORMERS

By

E. H. Stivender

TRANSFORMERS, as a rule, require little attention as compared to mechanically rotating machines for like service but must have particular care regarding overheat at normal load and protection from overloads. A number of different types of remotely located controls and instruments have been devised which greatly facilitate these operations in modern power systems. Alarms to indicate incorrect flow of cooling water in water-cooled transformers are made to be located at considerable distances away and remotely controlled temperature indicators and circuit breakers suffice to centralize all operations at one control point.

When a large transformer or transformer bank supplies a single feeder independently of a secondary bus, overload trip protection for automatically opening the transformer circuit breakers is employed; but where it supplies a number of feeders in multiple, no overload protection other than alarms and indicators is used, as a rule, and when overload trip protection is used the time and current settings are made for greatly abnormal conditions. In some of the later central and substations where several transformer banks with the primary and secondary bus supply a common load, transformers guaranteed to stand 100 per cent overload for a certain length of time are used. This practice makes it possible for one bank to be taken out of service temporarily without necessitating a reduction in load. Three single-phase transformers are often used in preference to high-voltage polyphase transformers for large transmission banks, owing to their greater repair facilities and the possibility they allow for the use of a spare unit in case of breakdown of one transformer. The spare can be arranged to be cut into circuit by the closing of disconnecting switches or be mounted on rails so it can be moved into the defective unit's place in short time. When three single-phase transformers are connected closed delta on the primary and secondary sides, they offer the advantage of allowing two units to be connected open delta if one unit should break down, whereas, the breakdown of one three-phase transformer so connected would require the removal from service of the complete transformer.

Protection from overload on transformers is accomplished by (1) fuses, (2) temperature relays, (3) overload relays, and (4) differential relays.

The use of fuses is limited to smaller lighting and power transformers and instrument transformers, due to their relatively small current capacity and the difficulty of replacement. The expulsion fuse has wide use with equipment of the 2200 and 6600-v. class, also the cutout or plug type is used extensively for small load service.

Temperature indicators and recorders are now being used extensively in central and substations. Recorders, as a rule, are furnished with auxiliary contacts to operate an alarm or trip the high and low-tension circuit breakers when the temperature reaches a predetermined value. Sometimes a separate temperature relay is employed for the service needed, in this case it may consist of contacts operated by a thermometer or an electrical instrument depending for its action on exploring coils or thermocouples inside the transformer. When a temperature relay is used for an alarm, it often indicates on the same annunciator as the incorrect water flow alarm mentioned earlier.

Protection by Temperature Relays

It is rapidly becoming standard practice to regulate the load of a transmission bank by the temperature indications rather than to base it on wattmeter, power factor meter and reactive kv-a. meter readings.

Figure 1 illustrates schematically a temperature relay of the Westinghouse Company with the trip circuit omitted, which has characteristics enabling it to be used for services where the use of ordinary thermostat instruments would be prohibitive. From the illustration: there are four resistor elements, A—B—C—D, connected to produce the effect of a Wheatstone bridge. The two coils A and B are copper exploring coils embedded in the windings and core of a power transformer while coils C and D are fixed resistance coils mounted near the relay element. The relay element consists of three coils E, F and G wound on a specially designed core of iron punchings. F and G are in series and connected across the junction of A—C and B—D, therefore, corresponding to the galvanometer of the bridge

circuit. Owing to its connection across the current transformer leads, coil E serves to complete the rotating field flux circuit acting upon a revolving disc which carries the contacts operating the circuit breaker trip coil circuit. Due to the bridge arms A—C and B—D being of equal resistance at normal transformer temperature, no current will flow through coils F and G and there will be no torque exerted on the disc, which is held in the contact-open position by coil springs, as in induction overload relays. Should one exploring coil increase in resistance, as when the transformer's windings increase in temperature, the balanced forces in F and G are destroyed and a current flows through them causing the disc to rotate and closing the contacts. Since the field strength depends upon the current through E which is proportionate to the transformer winding current and since the movement of the disc is retarded by drag magnets as in a watthour meter, the closing of the contacts depends upon three conditions: that the transformer must be of a certain predetermined temperature, that the load current must be equal to or over a certain value and that these two conditions must last for a determined length of time. These conditions make a relay with these characteristics preferable to any other type of protective temperature relay used with large transmission banks.

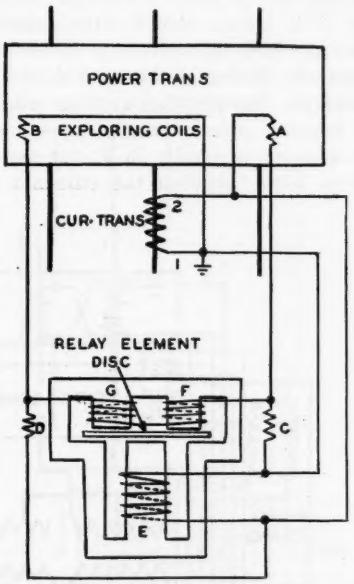


FIG. 1. CONNECTIONS OF A WESTINGHOUSE TEMPERATURE RELAY

Overload relays generally operate only an indicator or an audible alarm to warn the operator of impending danger, then it is left to his discretion as to when the load shall be discontinued.

Reverse power overload relays, phase balance and reverse phase relays are now being used to some extent where transformers furnish power for motors or rotary converters. These relays, though sometimes tripping the transformer circuit breakers, are intended mainly for the protection of the load equipment.

For opening the circuit breakers to prevent damage should a short circuit, partial short circuit, or ground occur, differentially connected relays are employed which, depending upon the locations of the operating current transformer, may also operate with a fault in any of the auxiliary equipment as in circuit breakers and their intermediate lead connections.

In order to permit a more thorough understanding of the transformer differential relay scheme, the following brief discussion is presented:

Three-phase power transformers are connected delta-delta, Y—Y, Y—delta, and open delta. In a delta connection, the voltage between any two leads is equal to that between any other two leads and equal to the voltage across the terminals of any of the three single-phase windings, while the amperage of each line is the amperage of the single-phase winding multiplied by the constant 1.732, or the square root of 3. In the Y connection, the voltage is the same between any two of the three lines and equal to the product of the voltage of any line to the neutral multiplied by 1.732. This value is the same as the voltage across any winding multiplied by 1.732. The amperage of any line is the same as the amperage of its corresponding winding.

Owing to the voltage to the neutral being much less than line voltage, the neutral in modern high-voltage systems is grounded either direct, or through a resistor to decrease impedance losses and also decrease the cost of insulation required. Where high-voltage delta-connected systems are used, it is sometimes found advisable to place large reactance coils, called grounding transformers, between each line and ground, each grounding transformer, of course, having the same characteristics.

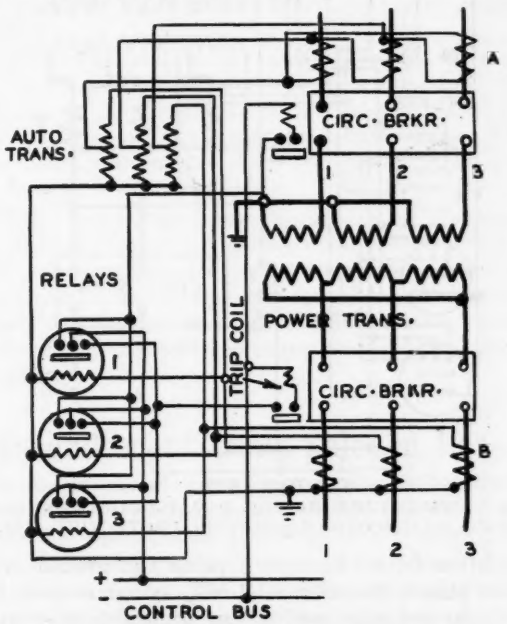


FIG. 2. WIRING DIAGRAM FOR A THREE-PHASE DELTA-STAR CONNECTED TRANSFORMER BANK

In high-voltage, alternating-current circuits, the effect of the third harmonic which, being out of phase and frequency with the power current, is manifested greatly in the form of increased impedance by limiting the flow of large currents. To minimize this effect, the low-tension windings are usually connected in delta, in which case the current of the low side will be 30 deg. out of phase with that of the high or Y connected side. Where high-voltage transformers are connected Y—Y,

as when used for the interchange of power between two delta-connected systems, it is usually obligatory to use the delta-connected tertiary winding in order to permit a path for the third harmonic; sometimes it is desirable to use this winding to supply low-voltage power. Even where Y-connected auto transformers are used for the inter connection, it is necessary to use the tertiary winding.

For protecting transformer windings and cores against the often disastrous effects of internal faults, as

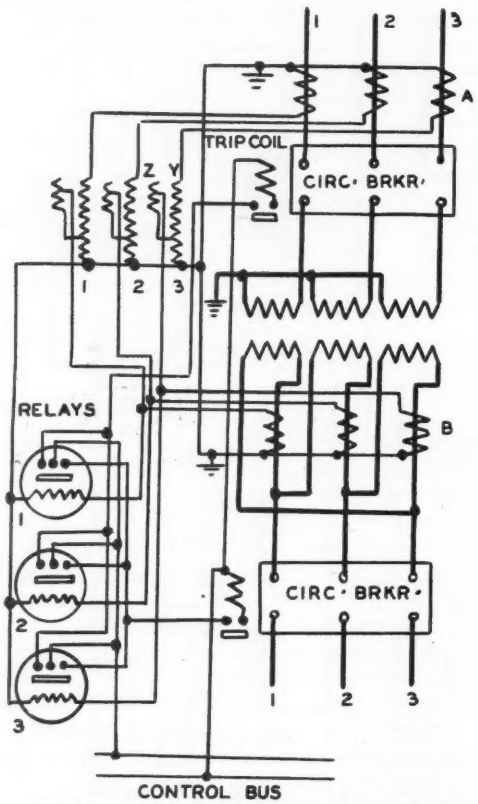


FIG. 3. WIRING DIAGRAM OF A STAR-DELTA CONNECTED POWER TRANSFORMER SHOWING PROTECTIVE RELAYS

insulation failure between a phase and ground or between phases, the differential relay system is used. This is by far the most used of any protective relay application in operation with large transformers. Since it acts immediately on comparatively weak currents, it has great value for clearing the apparatus when a short occurs near the grounded end of the windings and does not show appreciably on other protective instruments.

Protection of Y-Delta Transformers

In this system, the principle made use of depends upon equal and opposite electrical forces across induction relays, and when these forces become unequal the relay operates, tripping out the circuit breakers. Figure 2 is a diagram of such a system for three-phase delta-star connected transformer banks, with the protection of the circuit breakers also. Small auto transformers are required where standard five-ampere secondary current transformers are used, owing to the required delta connection of the current transformers on the Y side. These auto transformers are made for special current ratios having taps to obtain the ratio required, which in this case is theoretically 8.66 to 5. The auto transformers shown in Figs. 3 and 4 are the double winding type which are adjustable to a wider range of ratios. The instantaneous direction of current in phase 1 secondary circuit is such that the forces are opposing and of equal values across relay No. 1. Similar conditions govern the effects of the other two phases on relays 2 and 3. Should any fault occur in the power equipment between current transformers A and B these balanced forces are destroyed and current flows, operating the relay corresponding to the phase in which the fault occurs.

In Fig. 3 is shown the Y-delta connected power transformer in which the delta side differential current transformers are placed in the section of the winding leads between the line junction and the windings. This connection requires current transformers A and B to be similarly connected, generally in Y; for there is now no 30-deg. phase angle between the currents in the pri-

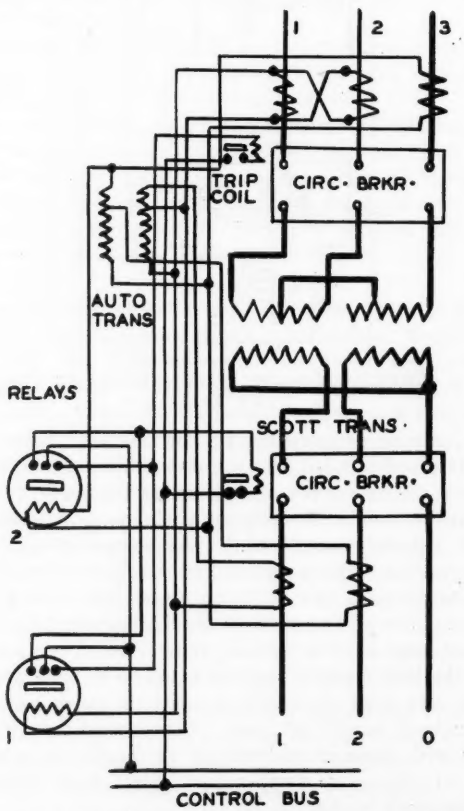


FIG. 4. APPLICATION OF RELAY PROTECTION TO A SCOTT CONNECTED TRANSFORMER

maries of the current transformers A and B. It cannot, however, afford protection of the delta side circuit breaker.

Such a connection sometimes eliminates the need of step-down auto transformers, for with standard five-ampere secondary current transformers equal currents are normally flowing in both sets of secondary leads. Often the current transformers in the delta side are in the power transformer bushings with taps brought out to terminal blocks on top of each transformer. Auto transformers shown in Fig. 3 illustrate the action of the double winding secondary auto transformer. Those

being discussed have each a total of 190 turns on the main winding with taps at 105, 115, 125 and 135 turns. The auxiliary windings have 5 turns, tapped at every turn. When used in a condition like that in Fig. 2 where the desired ratio is 8.66 to 5, the 5-amp. circuit contains the full 190 turns of the main windings and the 8.66-amp. circuit will require approximately 111 turns. To produce this effect, the 115-turn tap on the part Y is connected to the 4-turn tap on the auxiliary winding Z in such a way that the flux of the four turns of Z will oppose the flux of the 115 turns of Y, causing the transformer to have a ratio of 190 to 111 or 8.66 amp. to 5 amp. approximately.

Values of the current transformers secondary currents given here are assumed, their exact value depending upon efficiency and characteristics of the apparatus,

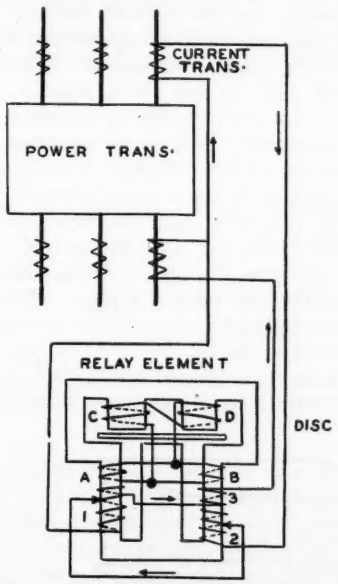


FIG. 5. A SCOTT CONNECTED TRANSFORMER WITH DIFFERENTIAL PROTECTION FOR CIRCUIT BREAKERS

and the exact auto transformer ratios must sometimes be found by trial.

Protection of Scott Transformers

A two phase-three phase Scott connected bank requires only two relays for differential protection. Similarly, a three phase-six phase bank would require only three relays. In Fig. 5 is a Scott transformer with differential protection of circuit breakers and using standard current transformers. Three current transformers are used on the three-phase side, two of which are cross connected in order to produce the required 90-deg. phase displacement from the remaining current transformer and therefore synchronism with one leg of the two-phase side. Since in the Scott connection one line of the two-phase side differs 180 deg. from one line of the three-phase side, no special current transformer connection other than the reversing of the leads of one transformer is necessary for the relay connection, hence. two corresponding current transformers are connected independently of the others to a separate relay, as relay No. 2, Fig. 4. The remaining transformers act upon relay No. 1.

Note: This is the first of two articles dealing with the protection of large transformers by Mr. Stivender. The second will appear in a subsequent issue.

Sixty-Cycle Equipment Most Popular

Direct-current flows only in one direction conventionally assumed as from the positive to the negative pole, although we know now that the actual flow, that is the electronic flow, is from the negative to the positive pole. This kind of current cannot be transmitted for long distances, due to losses in conductors of reasonable size and excessive cost of conductors of large size.

For this reason, it has gone out of use except in a few of the older thickly settled metropolitan districts, for street railways and certain auxiliary and control devices requiring closely regulated and variable motor speed.

Alternating current, on the other hand, flows first in one direction and then in the other; each time the direction changes, it is known as an alternation and two alternations make a cycle. The number of cycles per second is known as the frequency.

In the early days, no standards were available and manufacturers made their own and used the frequency that best suited their needs. The frequency is determined by the speed and number of poles of the generator and gradually 25, 50, and 60-cycle current became standard.

All three are still in use to some extent but the tendency is toward the use of 60 cycles as standard. The first, that is 25 cycles, was particularly suited to low speed water wheels and is confined to that service. This is the lowest practical frequency and even then lamps on this frequency seem to flicker.

With the growth of large interconnected systems, a standardized frequency allowing the different plants to be connected without the use of frequency changes became advisable and as 60 cycles seemed best to meet the needs of lighting, motor speeds and high turbine speeds, this frequency is rapidly becoming standard throughout the country.

Incandescent Lamp Sales in 1929

Sales of incandescent lamps in the United States during 1929 were approximately 340,000,000 large and 292,000,000 small lamps, according to a review of the electrical industry for the year by John Liston of the General Electric Co. This is an increase of 18,000,000, or a little over 5½ per cent in the large sizes over the previous year, and an increase of 37,000,000, or 14½ per cent in the small sizes.

"These 1929 sales exceed all previous figures, being the largest in the history of the industry," according to Mr. Liston. "On March 1, 50- and 60-w. standard lighting lamps of the 115-v. group were reduced in list price from 22 to 20 cents so that the 20-cent price now covers all the generally used lamps up to and including the 60-w. size. The price trend for lamps has been downward for a number of years; the present prices being less than half the so-called pre-war figure.

"Compare this with the present cost of living, which is now 60 per cent above the pre-war level, a peak of 100 per cent increase having been in effect during 1920. While the average prices of lamps did go up during the post-war period, their increase was less than one-tenth that of the increased cost of living during the same period."

Electricity---What It Is and How It Acts*

PART XXXIV. THE INERTIA EFFECT IN ELECTROMAGNETIC WAVES. RELATIONS BETWEEN THE INDUCTION AND RADIATION FIELDS. BY A. W. KRAMER

IT IS ONE THING to demonstrate the production of a wave in a rope as was done in the preceding chapter and quite another to show the principles underlying the production of electromagnetic waves in space. It is a simple matter to think of inertia and mass in the case of a rope and a comparatively easy matter to visualize the part played by these properties in producing a traveling wave but when we try to visualize

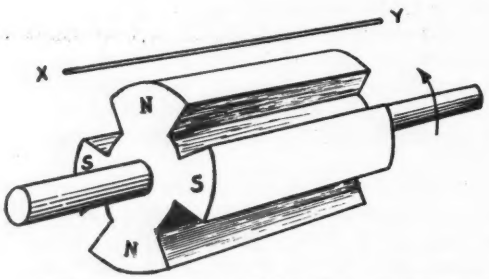


FIG. 1. GENERATION OF AN E.M.F. IN A CONDUCTOR BY A MOVING MAGNETIC FIELD

This diagram shows the revolving field of a generator and a single armature conductor. As the pole pieces move past the stationary conductor, the magnetic field sweeps the conductor and induces in it an e.m.f. It is not generally understood, however, that the difference of potential induced between the ends of the conductor x-y will be produced in the space whether the wire is there or not.

or imagine such properties as belonging to the electric field in space, we find the analogy of little assistance although we must admit its logic.

The difficulty, of course, lies in our utter inability to visualize energy transformations in a space that all our senses tell us is empty even though we draw all sorts of pictures and diagrams to show what must go on in this space. Thus Faraday invented his tubes of force and so our conception of an ether arose. The workings of the non-mathematical human mind is limited to a large extent by its power to visualize and for this reason pictures and analogies are resorted to. There is no particular harm in this as long as we do not take our analogies too seriously or to believe that their counterparts actually exist in the invisible world or electric and magnetic energy.

MAGNETIC FIELD PRODUCED BY A MOVING ELECTRIC FIELD

In the preceding article, we showed how the inertia of the parts of a rope was responsible for the outward motion of a bulge or wave, when one end of the rope was displaced suddenly. What we shall endeavor to show now is that there is an inertia effect in the electric field surrounding an oscillator or antenna which is responsible for the outward motion of an electromagnetic wave. This, it will be recalled, was already explained in an elementary way in Chapter XXXI and while this explanation may be satisfactory, it does not explain it in terms of the electric and magnetic fields with which we are familiar in electrical engineering.

To do this, it is necessary to revert briefly to the discussion of the production of magnetic fields in an early chapter.[1] It will be recalled that there is associated with the electric current an inertia effect due to the energy storage in the magnetic field surrounding the conductor. As the current changes, the magnetic field also changes, causing electromotive forces to be induced which tend to oppose the change in current, thus giving rise to an effect similar to inertia in mechanics. In other words, a magnetic field cutting across a conductor, induces an electromotive force in the conductor. This principle is employed in every electric generator in the manner shown in Fig. 1. Here a revolving magnetic field generates an electromotive force in the conductor X-Y, the end X becoming positive and the end Y negative, this polarity reversing when a south pole takes its place. This principle is well understood and requires little comment. What is not so well understood, however, is the fact that the moving magnetic field produces a difference of electric potential whether the conductor is there or not.

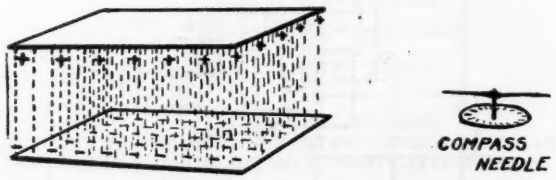


FIG. 2. A MOVING ELECTRIC FIELD GENERATES A MAGNETIC FIELD

By moving the two charged plates horizontally so that the electric field between them passes over the magnetic compass needle, the latter will be deflected, showing the presence of a magnetic field. This magnetic field is at right angles to the direction of the field and to the direction of motion of the field.

Another point not generally understood is the reverse relation, i.e., that a moving electric field produces a magnetic field. This should not be surprising, when we consider that an electric current produces a magnetic field. An electric current is nothing more than a stream of electrons and it is really the moving electric fields of these electrons that produces the magnetic field. The magnetic field around a stream of electrons shot out from the cathode in the cathode ray tube[2] is exactly the same as that surrounding a stream of electrons in a conductor, although in the cathode ray the conductor is absent.

To show that a moving electric field produces a magnetic field, an experiment has been devised, using two oppositely charged plates and a compass needle, as shown in Fig. 2.[3] Suppose that the two metallic plates

*All rights reserved.

[1] Electricity—What It Is and How It Acts, Vol. I, Chapter XIV.

[2] See Chapter XV.

[3] Principles of Radio Communication, by J. H. Morecroft, 2nd edition, page 811.

are charged so that an electrostatic field exists between them. A compass needle is mounted so as to be free to rotate in a horizontal plane. The plates are arranged so that they can be moved horizontally in such a manner that the compass needle will pass between them. If, at the beginning of the experiment, the needle is oriented in the same direction as the motion of the plates, it will be found, as the plates move by, that the needle will set itself at right angles to the direction of motion and will maintain this position as long as the electric field is moving past it. This experiment, while somewhat difficult because of the comparatively low velocity with which the field can be moved, demonstrates that a magnetic force is produced by the moving electric field. This magnetic field as indicated by the compass needle is always at right angles to the electric field and also to the direction of motion.

Now we can begin to understand what occurs in the vicinity of a charged conductor or radio antenna.

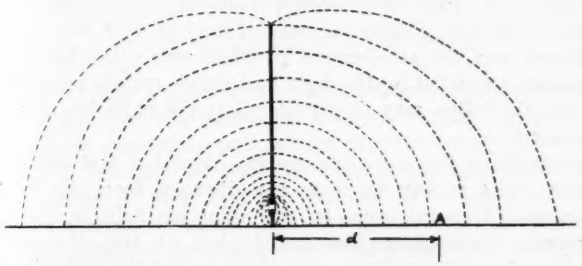


FIG. 3. THE ELECTRIC FIELD SURROUNDING A VERTICAL OSCILLATOR OR ANTENNA, THE LOWER END OF WHICH IS GROUNDED

A moving electric field is the same as an expanding or contracting electric field, that is one increasing or decreasing in intensity at any point in space. It is evident then that the expanding electric field around an antenna will be accompanied by a magnetic field. Since this magnetic field (and also the electric field which produces it) represents a storage of energy, we may expect it to exhibit an inertia effect, similar to that found in the ordinary magnetic field surrounding a conductor.

Fields Surrounding an Electric Oscillator

The stationary electric field around a vertically charged conductor or antenna looks like that shown in Fig. 3. In this case, the lower end is grounded and the electric lines of force extending from the upper part of the antenna, terminate on the ground within an area of which the antenna is the center. When the charge on the antenna was first built up, however, the field did not extend out as far as it does in Fig. 3, for while it is true that the field follows, both in direction and intensity, the charge on the antenna, because of the large dimensions of the field, we have to consider the time necessary for the field to reach a certain point. That is, the electric field at a point A, for example, will follow the variations of the potential difference between the ground and the antenna, except that the variations at A will take place later on account of the appreciable time necessary for the lines of force to travel the distance, d. It is evident, then, that a certain time after the charge has begun to accumulate (it is assumed that this process of building up the charge is very rapid) the electric field will extend outward only a finite distance, say a little beyond the point A. At A, the electric flux has been increasing, that is, it has been moving outward; therefore, in accordance with the principle described above, the electric field has become surrounded with a magnetic field. This field, being at right angles to the direction of the electric flux and also to the direction of motion, takes the form of concentric circles around the antenna. In Fig. 4 is shown a simple Hertzian oscillator with both the electric and magnetic force indicated. The direction of the electric field E it will be noted is at right angles to the direction of magnetic force M.

Since these electric and magnetic fields represent energy and since this energy is being stored in space at the expense of the charge in the antenna, the first effect of these fields is for them to reach out only a finite distance. The fields cannot reach their full development instantly but must increase at a finite rate, due to the storage of energy in space. In other words it is as though the electric field were endowed with the property of inertia.

When the charge in the antenna reaches its maximum value and starts to decrease, the electric field at a point A, in Fig. 3 for example, cannot at once stop increasing and start to decrease; for by virtue of the magnetic field surrounding the changing electric flux,

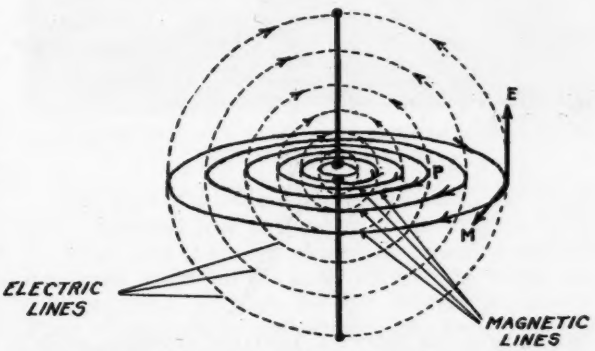


FIG. 4. THE ELECTRIC AND MAGNETIC FIELDS SURROUNDING A SIMPLE VERTICAL HERTZIAN OSCILLATOR

there is inertia, and some time must elapse before the force at A can stop increasing. Thus it comes out that when the charge on the antenna has been reduced to zero there are still lines of electric force out in space in the neighborhood of A. An electromagnetic "bulge" has been produced in space just as a bulge was produced in the rope. The energy represented by these lines of force thus left isolated out in space, cannot remain stationary but must travel outward. This, however, could not happen were it not that, at the same time and for the same reason that a certain amount of energy is left detached at any point in the form of an electric field, an equal amount of energy in the form of a magnetic field acting in a horizontal direction as shown at P (Fig. 4) also remains at each point. These two energies, moving outward with the velocity of light, can thus sustain each other and are completely independent of the conductors from which they issued. For it must be kept in mind that a moving electric field produces a magnetic field, and vice versa.

Thus, we see that the radiation of electromagnetic energy is similar to the radiation, so to speak, of mechanical energy along a rope. The wave in the latter case, consisted of points on the rope which were displaced and which were also moving. The electromagnetic wave sent out from an antenna consists of a combination of electric and magnetic fields, the intensity of which at various points in space varies in accordance with the variations in antenna current. If this variation of antenna current is harmonic, the variation of the detached field at any point will be harmonic. The increasing electric field at any point creates a magnetic field and this field in turn creates an increasing electric field. Thus they travel together through space, one producing the other.

Electric and Magnetic Fields Are in Time Phase

This interaction of the electric and magnetic fields is rather difficult to explain and still more difficult to visualize. The point to be remembered is that each type of field, produces the other type of field, proportional to its own intensity. These fields are at right angles to each other in space but *in time they are in phase.*

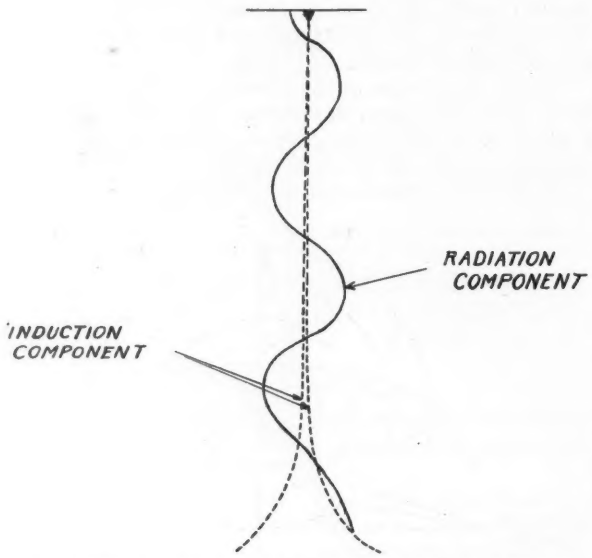


FIG. 5. DIAGRAM SHOWING ANALOGY BETWEEN INDUCTION AND RADIATION FIELDS SURROUNDING AN ELECTRIC OSCILLATOR AND THE WAVES PRODUCED IN A ROPE

The last fact is often misunderstood, as it is assumed that the magnetic field is at a maximum when the electric field is at a minimum and vice versa, the energy being connected from one form to another in successive instants of time. This, however, is not true. The magnetic field reaches its maximum at the same time that the electric field reaches its maximum and in the same way they reach their minimum values at the same time.

From this discussion of electric and magnetic fields around conductors, it must be evident, from what was said in previous chapters, that the space about an antenna is occupied by two components of electric and magnetic fields. One of these is continually moving backward and forwards from the antenna, so that energy is alternately given to it by the antenna and returned by it to the antenna. Thus are the electric and magnetic fields considered in connection with inductance and capacity in earlier chapters. Because of this backward and forward motion the average displacement of this component of either field is zero. This component known as the induction field is the one with which electrical engineers are more familiar.

The other component of either field is the one which, having left the antenna, is prevented from returning to it and thereafter travels outward with the velocity of light. This is the radiation component. This component, although fundamentally of the same nature as the induction component, is nevertheless very different, for it is completely detached from the antenna. The induction component may be compared to the potential stored energy in lifting the lower end of the rope in the previous article to its extreme point of travel. This energy is recovered when the rope is permitted to swing back to the wall. That energy, however, which is represented by the product of mass of that part of the rope moved and the acceleration in other words, the kinetic energy imparted by the jerk, and which travels upward with the bulge, may be considered as the radiation component.

Both of the two components, induction and radiation, exist at any point at any distance from the antenna. At points near it, the induction field is much greater than the radiation field but at any distance away from the antenna, the intensity of the radiation field is so much greater than the induction field that the latter may be considered not to exist.[4]

This point also may be made clear by a consideration of the rope. In Fig. 5 is a diagram showing first the "induction" displacement of the rope throughout its length (shown dotted) and second, the "radiation" displacement (in full lines). Because of the inertia of the parts of the rope, the induction displacement falls off very rapidly, but the "radiation" displacement suffers little or no diminution in intensity. The amplitude of the induction field at any point varies as the square of the distance while that of the radiation field varies inversely as the distance.

Although it was stated in a foregoing paragraph that both the radiation and induction fields exist at any point any distance and although these two fields are represented simultaneously in Fig. 5, it must not be concluded that there are actually two fields. It is evident that a point on the rope could not occupy the position of the induction component and a point of maximum amplitude on the radiation component at the same instant.

At any point in space in the neighborhood of the radiating antenna, the electric and magnetic fields both go through harmonic variations. Close to the radiator these two fields are both of intense amplitude and they are nearly 90 deg. out of time phase. As the distance from the oscillator increases, both of these fields fall off in intensity and with decreasing intensity (a wave length or so from the radiator) the electric and magnetic fields are in phase.

Now it will be evident, why frequency is such an

[4]See "Principles of Radio Communication," by R. H. Morecroft, p. 817.

important factor in producing effective radiation. The higher the frequency, the more sudden will be the displacement and the more energy will be detached from the antenna. At the same time, the energy stored in the inductive field will be a minimum. It is for this reason that extremely high frequencies are used in radio work. It must not be thought that no radiation component exists at low frequencies, however, for a radiation component exists at any and all frequencies but, since the very reason for the existence of such a component lies in the inability of the energy given to a rapidly changing field to return in its entirety to the circuit giving out the energy, it follows that, for a slowly changing field, this effect is negligible. Thus, in low frequency circuits, the radiation component is never considered.

A New Idea in Dressing Commutators

By Austin C. Lescarboura

OF PARTICULAR interest to the power plant operator who has under his charge a number of direct-current generators and motors is a new stoning board which not only smooths down the rough spots in commutators of rotary converters and generators, but is also a safety device. This device which has been perfected by the Armature Division, Electrical Construction Department of the New York Edison Co., simplifies the work and can be operated with practically no danger to the man using it. There is a vacuum cleaner attached, which collects 60 per cent of the flying copper and stone dust.

This new stoning board replaces the old time method whereby a man had to hold the stone on the commutator with a wooden lever or pry about 6 ft. long. He had a hazardous job, as the commutator was run at normal speed during the process, or about 187 revolutions a minute, which is high speed as a commutator is either 8 or 10 ft. in diameter. There was always danger that the stone might topple over and severely injure the mechanic.

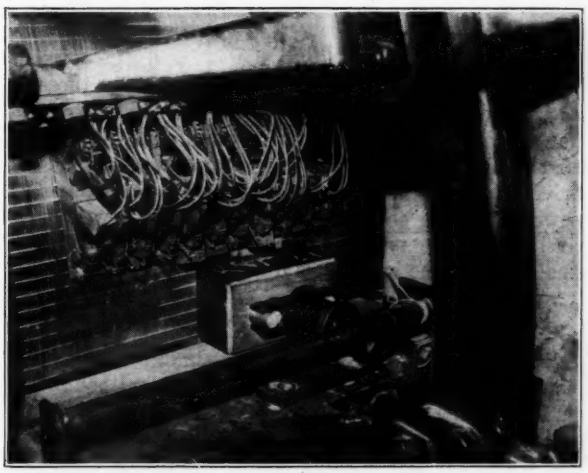
With the new device, the man operating the stoning board does not have to touch it except to make adjustments. As it is used extensively in substations, other large utility companies are expected to be greatly interested in the new piece of mechanism.

Stoning jobs are frequently necessary on the commutators. Small grooves wear in the bars, high tension feeder disturbance roughens them up considerably due to excessive sparking, and the bars themselves sometimes get out of alinement, termed high or flat bars.

As will be noted from the photograph, the stone is held in a rigid position on the board by a clamp. Just above the clamp is a heavy spiral spring which gives the proper tension to the stone. The spring is supported by a threaded brass member, with an adjustable nut, to keep the tension uniform as the stone wears during the process. This part of the mechanism is in turn attached to the long bar known as the traveler. A man operating it simply has to regulate the tension with a wrench or, when one rough spot is cleared, move the stone grip along the traveler to reach another spot.

Being made of micarta material this stoning board is of high insulating quality and very strong. All metal parts are insulated from the apparatus to be worked on. This reduces to a minimum the possibility of contact with any live parts. It is also impossible for the stoning board to come in contact with the cooling vanes on the outer edge of the commutator or with the commutator risers that connect to the armature windings.

A trough with a vacuum connection is attached to the stoning board in such a way that 60 per cent of the copper and stone dust goes into the vacuum cleaner. This minimizes the danger of copper lodging in apparatus being stoned or operating in the vicinity. Copper dust has been known to cause some expensive short circuits.



STONING BOARD FOR DRESSING COMMUTATORS USED BY NEW YORK EDISON CO.

This type of stoning board can be set up in 10 min. and dismantled just as quickly. It is attached to the d.c. brush arm of the apparatus. By removing only one d.c. brush holder on the outer edge of the brush arm, sufficient room is made for the vacuum attachment. Many stoning jobs on commutators have been performed with the stoning boards without an accident while doing this hazardous class of work.

In the course of investigations to find the cause of breakdowns in lead cable sheathings, the British Non-Ferrous Metals Research Association discovered a new alloy which consists of 98.25 per cent lead, 1.5 per cent tin and 0.25 per cent cadmium. According to a bulletin of the Anglo-Oriental Mining Corp., Ltd., tests show that it possesses the following advantages over pure lead: Pipes made from it will be cheaper, having only two-thirds the weight; its ultimate tensile strength is 84 per cent greater; its resistance to vibration is 217 per cent greater; in certain corrosive waters its resistance is superior to lead itself.

The force of gravity on a round body is about one-quarter of one per cent greater at 60 deg. north latitude than it is at 30 deg. north latitude and is also about one-sixteenth of one per cent less at 15,000 ft. elevation than it is at sea level. This slight difference at different places of the earth is of no consequence, however, except in the most precise scientific work.

Analogy drawn between

Ammonia Refrigerating *and* Steam Power Cycles

SIMPLE COMPARISONS OF REFRIGERATING AND STEAM PLANT OPERATION CLEARLY SHOW REASONS FOR CERTAIN TEMPERATURE AND PRESSURE EFFECTS BY MEANS OF DIAGRAMS. BY P. F. ROGERS

MANY POWER plant engineers, especially those in industrial plants, have large amounts of refrigeration or cold storage to look after and, since practically all of the newer ice and refrigeration plants are motor driven, many engineers now have little to do with steam power. On the other hand, many plants have a relatively small ice machine, whose attendance is only a small part of the engineer's duties.

SIMILARITY OF REFRIGERATION AND STEAM CYCLES

The refrigeration cycle is quite similar to, but even simpler than, the boiler and engine cycles although the equipment arrangements differ slightly. Figure 1 depicts a typical, simple, steam plant cycle in which steam and water are the working fluids. Sequence of events is in a clockwise direction. Water goes into the boiler, absorbs heat, is vaporized, is then piped to the engine cylinder where it expands and does work, after which it passes to the condenser where the latent heat is given up. The fluid, as water, is then put back into the boiler by a feed pump through the feed valve where a pressure drop takes place and the cycle is repeated.

Figure 2 represents a typical simple refrigeration compression system. Ammonia enters the coils where it absorbs heat, is vaporized, then is passed to the compressor where it is boosted in pressure and finally goes to the condenser where the latent heat is abstracted and the gas condensed into a liquid. It is then released through an expansion valve into the cooling coils and the cycle repeated.

The only real difference between the two cycles is that the pressures in different parts of the systems differ and the action of the steam engine is a reversal of that of the refrigeration compressor. Also, the refrigeration system is simpler, since no pumps are necessary to feed the fluid into the ammonia "boiler." Slight reflection will show that the action of the boiler and of the refrigeration coils is identical. In the boiler, the water absorbs heat from the gases of combustion, while in the refrigeration coils the ammonia absorbs heat from the brine. In each case, the liquid is warmed up while the other medium, that is gases or brine, is cooled. Either one is a boiler, when considered from the standpoint of the working medium or either one is a refrigerator, when considered from the standpoint of the medium supplying the heat.

It is common to hear that the refrigeration cycle is just the reverse of the steam cycle when, as a matter of fact, it is not the reverse; the cycle is the same as can be seen from Figs. 1 and 2. The only real difference is that the action of the engine is reversed. The pressures and temperatures vary as shown, in the same parts of the similar systems.

With 170 lb. abs. pressure the steam temperature, as taken from the steam tables, would be 368 deg. F. The engine would exhaust this steam to the condenser at about 25 in. vacuum. Here it would be picked up and sent to the boiler feed pump by the hotwell pump and would probably reach the feed valve at about 185 lb. and flow into the boiler. Assuming 70 deg. water

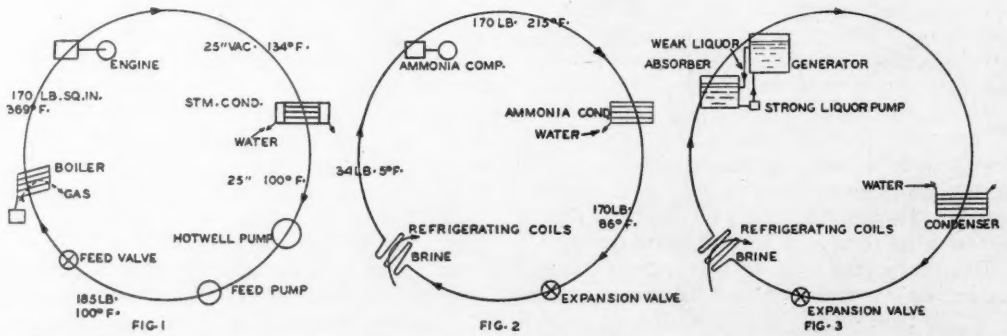


FIG. 1. SIMPLE STEAM PLANT CYCLE FIG. 2. SIMPLE AMMONIA COMPRESSION REFRIGERATION PLANT CYCLE FIG. 3. SIMPLE AMMONIA ABSORPTION REFRIGERATION PLANT CYCLE

for the condenser, the head pressure in the refrigeration system might be maintained also at 170 lb. This corresponds to a temperature of about 86 deg., which would give a temperature difference of about 16 deg. between the water and ammonia, which, although not an unusually good value, is a good conservative one. This drop in pressure across the expansion valve depends upon the refrigeration temperature desired and upon the capacity of the compressor in relation to the load. If it is overloaded, the suction pressure will increase. Consulting ammonia tables, which are similar to steam tables, the pressure corresponding to 14 deg. temperature is found to be 42 lb. abs.

Regulation in Both Systems by Governing Flow

In a steam system, if the engine had no governor or throttle valve and the load dropped to, say one half, the only way to maintain pressures in the system would be to decrease the amount of steam coming from the boiler. In a refrigeration system, a similar action takes place. If the plant has been operating at constant load and the load is suddenly decreased, the brine will not receive as much heat as the ammonia vapor carries away; therefore the ammonia takes some of the heat from the brine itself and its temperature is gradually lowered. This must be stopped or the brine might freeze. The easiest way to do this is to cut down the amount of ammonia passing through the expansive valve. The compressor is therefore slowed down or the capacity changed by clearance pockets until the amount it handles is just equal to the amount passing through the expansion valve.

Characteristics of Refrigerants

Ammonia is the most widely used refrigerant because it requires only moderate pressures and seldom drops below atmospheric pressure. Other refrigerants are frequently used, however, among which are carbon dioxide and sulphur dioxide. Even water has been used in some big plants that have been successfully operated. Carbon dioxide is widely used in hotels and public buildings because it is odorless and harmless so that leaks are not serious or dangerous although they may be expensive. Pressures run up much higher, however, with these refrigerants than with ammonia, ranging upward from 1000 lb. per sq. in.

Sulphur dioxide is relatively harmless as compared with ammonia although, in sufficient concentrations, it is dangerous. The pressures necessary are not as high as those required for ammonia and this gas is being used quite extensively for household machines. Some of the physical properties of the three gases, compared with water, are given in the accompanying table. They are also shown in Figs. 4 and 5, which are drawn to the same scale on temperature-entrophy and heat-pressure diagrams. It will be seen that ammonia has only about half the heat capacity of an equal weight of water and that both CO_2 and SO_2 have still smaller heat contents than ammonia. If the heat capacity of ammonia is considered as 100, sulphur dioxide would be 31.6 and carbon dioxide would be 17.5, so that, for the same amount of refrigeration, about three times as much sulphur dioxide or about six times as much carbon dioxide by weight, would have to be circulated than would be the case with ammonia. This is only part of the story,

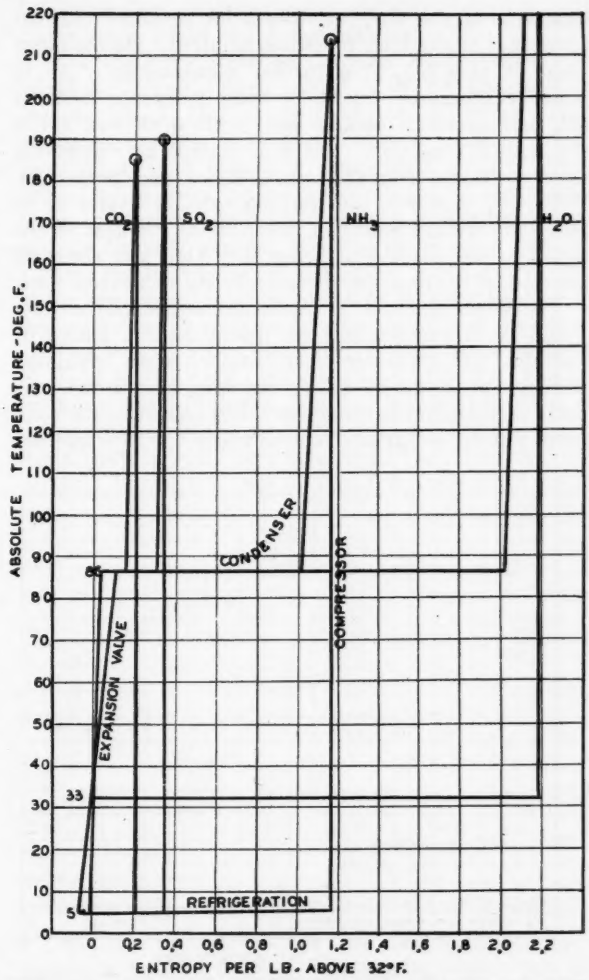


FIG. 4. CHARTS REPRESENTING THE COMPARATIVE PHYSICAL PROPERTIES OF VARIOUS REFRIGERANTS BY TEMPERATURE—ENTROPY DIAGRAMS

however, because the specific volume of CO_2 is much lower than that of either SO_2 or ammonia. In fact, at the suction conditions of the compressor where the volume of vapor is the biggest, the ratios of specific weights are about 3.1, 83 and 100 for CO_2, SO_2 and ammonia respectively; that is, the specific volume of CO_2 is only about one-twentieth that of ammonia.

PROPERTIES OF PRINCIPAL REFRIGERANTS

	Water	Ammonia	Carbon Dioxide	Sulphur Dioxide
Melts—deg. F.	32	—103	—112	—105
Boils—deg. F.	212	— 28	— 69	14
Crit. temp.	705	271	88	312
Crit. press.	3200	1653	1070	1115
Press. at 14 deg. F...	...	42	385	12
Press. at 86 deg. F...	0.6	170	1040	66
Density	62.4	42.6	95.5	93.1

Taking both weight and specific volume into account in order to determine the size of the compressor, it is found that if a 100-cu. ft. displacement is sufficient for ammonia, SO_2 would require 250 cu. ft. and CO_2 only 18.5 cu. ft. This gives CO_2 a big advantage because the

smallness of the machine does a lot to offset the disadvantage of the high pressures required. On the other hand, it puts SO_2 at a further disadvantage. As to power consumption, there is little difference between SO_2 and ammonia because they both work well below the critical condition. Sulphur dioxide and ammonia show a decided similarity in behavior and properties. With CO_2, however, the working cycle is nearly at or above the critical condition, the ratio of the heat of the liquid to the latent heat being very high and about 40 per cent of the liquid evaporated by its own excess heat.

As shown in Fig. 4, the cycles are not exactly as they would be in practice but are drawn as if a pound of material at condenser temperature were expanded through the expansion valve, absorbing heat in the coils until vaporization is completed, then passed to the compressor to be compressed adiabatically to the condenser

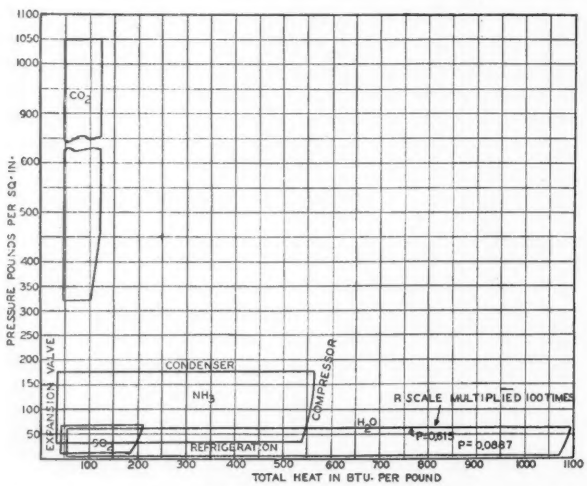


FIG. 5. CHARTS REPRESENTING THE COMPARATIVE PHYSICAL PROPERTIES OF THE SAME REFRIGERANTS COMPARED IN FIG. 4 BY HEAT-PRESSURE DIAGRAMS AND SHOWING THE HEAT ABSORBED AND DISCHARGED BY THESE REFRIGERANTS AT VARIOUS POINTS OF THE CYCLE

pressure and then cooled in the condenser until liquefaction is complete. As a matter of fact, it will probably be cooled a little lower than this by the counterflow condenser and will reach the compressor slightly superheated but, for our purpose, such small differences were disregarded in our simple chart.

Comparison of Absorption and Compression Systems

In the absorption system, there is no compressor. In order to get the ammonia from the low suction to the high head pressure, subterfuge is resorted to, the ammonia being first absorbed in comparatively cool water at low pressure. This mixture of water and ammonia then is pumped to a higher pressure where the water is heated by steam coils and the ammonia driven off.

Such a system is shown in Fig. 3. Comparing this with Fig. 2, it will be seen that the only difference between the absorption and compression systems is the substitution of two tanks and a pump for the compressor. After leaving the refrigeration coils as a vapor, the ammonia goes to the absorber which is partially filled with water. Ammonia is readily soluble in water and the colder the water the more ammonia will be absorbed. This water and ammonia solution, now known as "strong liquor," is pumped back by the strong liquor pump to the generator which is simply an insulated tank supplied with steam coils. The liquid is heated by steam coils in the generator and the ammonia, which is driven off, passes to the condenser and is liquefied. The water which now contains only a small amount of ammonia is known as "weak liquor." This is returned to the absorber for another charge of ammonia.

Absorption System Has Field in Hotel Plants

Formerly, the absorption system was used more widely than it is now because, being operated with low pressure exhaust steam, it worked in nicely with non-condensing engines. It still has a considerable field such as in a big hotel plant where the refrigeration load can be divided between compression and absorption systems so that they act as an accumulator or balancing device between the steam and electric loads. If more electric load is needed than can be supplied without creating an excess of exhaust steam, the compressor load can be cut down and the refrigeration load shifted to the absorption system. This reduces the electric load and increases the steam load and so helps to balance conditions. If there is not sufficient electric load to supply the necessary steam, the refrigeration load can be shifted from the absorption to the compression system and so the steam load can be cut down and the power load built up. Unfortunately, the average plant does not have sufficient refrigeration capacity to have much effect on the heat balance of the plant as a whole but there are hotels where such systems are used with great satisfaction.

After many years' experience with a steam system, it does seem hopeless for an engineer to be expected to master all the intricacies of something which the majority of people insist works backwards compared to any steam power plant. By keeping in mind diagrams, Figs. 1 and 2, the matter becomes somewhat simpler and when you can see in graphical form the simple relations that exist between the units of your own plant, it is a little easier to understand how the temperature affects the condenser pressure directly and why the suction pressure and brine temperature drop with a small load or increase with a heavy load.

In engineering and mathematics, it is often convenient to express an angle in radians rather than degrees. The radian is a natural unit of measurement and it is equal to the angle included between two radii of a circle when the arc of the circle between them is equal to the radius. Thus, if the radius is r, the length of arc would be r and the angle would be one radian. Inasmuch as the circumference is $2 \pi r$ a complete circle is 2π radians, so that in degrees 2π radians equals 360 deg. and one radian equals approximately 57.5 deg.

Organic sulphur occurs in coal as a residue from the original organic matter and also in a mineral form chiefly as iron pyrites, in lumps, flakes or thin veins. It may also be present in the gypsum, the thin, white flaky substance sometimes seen on a freshly broken coal face.

1400-Lb. German Station Uses Steam Reheaters

MANNHEIM-RHEINAU SUPERIMPOSES 1420-LB. EXTENSION ON ORIGINAL 285-LB. SECTION. BY C. H. S. TUPHOLME

AN EXAMPLE of the latest European power plant practice is found in the case of the new 1420-lb. plant which has been built as an extension of the central electricity station Mannheim-Rheinau in Germany, where the original boilers worked at 285 lb. With two super high-pressure boilers, each evaporating 135,000 lb. of water per hour, the capacity of the station has been increased by installing primary regenerative turbines of 7000 and 4500 kw., a back-pressure turbine of 4500 kw. and a regenerative primary engine of 700 kw.

Boilers are fed by four high-pressure pumps, each delivering 200,000 lb. of water per hour, two of them direct-coupled to steam turbines operating with steam at 225 lb. and two driven through speed-increasing gearing by three-phase electric motors. The sketch shows diagrammatically the layout of the machinery and apparatus. The steam pressure falls from 1420 to 285 lb. per sq. in. atmosphere in the primary turbines, V, and then passes through intermediate steam reheaters, Z, to the main condensing turbines, H.

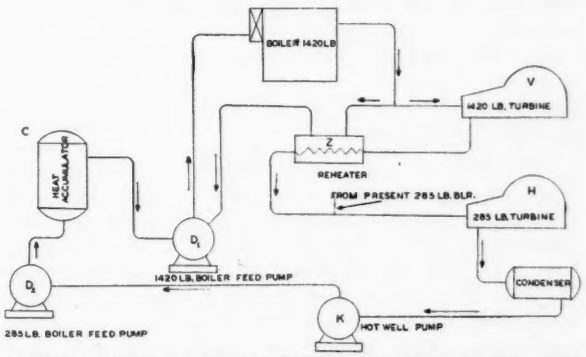
Condensate is withdrawn from the condenser by a two-stage condensate pump, K, which is combined in one pumping set with the cooling water and injection water pumps. The condensate, together with the quantity of make-up feedwater required, is then led, at a temperature of about 176 deg. F. to the intermediate pumps, D_2, which deliver the water into a system of constant pressure heat accumulators, where its temperature is raised almost to the evaporating point. From there the water flows at a temperature of about 390 deg. F. and under a pressure of 265 lb. to the nine-stage high-pressure feed pumps, D_1. Each of these pumps delivers normally 200,000 lb. per hour and increases the pressure by 1325 lb., so that the pressure at the end of the ninth stage is 1590 lb. At this pressure the water is passed through the economizers into the 1420-lb. boilers. The four four-stage, centrifugal pumps, D_2, each delivering 276,000 lb. per hour against a total head of 25 atmospheres, 355 lb., are driven-direct-coupled, by 180-hp. three-phase motors running at 2900 r.p.m.

In the reheater, Z, the exhaust steam from the turbines, V, at a pressure of 285 lb. and a temperature of 480 deg. F., is brought to about 660 deg. F., before it enters the main turbines. For this purpose, live steam at a pressure of 1420 lb. and a temperature of 860 deg. F. is passed through the reheater, along the outside of the tubes carrying the 280 lb. steam. Condensate at a temperature of 510 deg. F., corresponding to a saturation pressure of 1335 lb., is introduced into the feed system through an auxiliary branch into the high-pressure boiler feed pump between the sixth and seventh stages at a pressure of 1220 lb.

When the feed pumps are delivering a small quantity of water, the hot water thus introduced may cause the temperature in the last stages of the pump and behind the balancing disc to rise to a dangerous point so it is necessary either to cool the water led to the balancing disc, entailing a loss of heat, or lead it back to the steam space of the accumulator.

For the new 20,000-kw. turbine which works with steam at 285 lb., taken partly from the intermediate superheater, Z, and partly from the old boiler plant, two pumping sets have been installed, each of which includes all the auxiliary condensing pumps. Each group comprises a cooling-water pump, an air ejector and a condensate pump, K. One set is driven by a steam turbine through gearing and the other by a 300-hp., 3-phase motor running at 735 r.p.m. Both pumps run at the same speed in order that they may be the same in construction. One set serves as a standby to the other.

The cooling water circulating pump has a capacity of about 14,700 g.p.m. against a head of 23 ft. The air ejector pump withdraws from the delivery chamber of the circulating pump the water required for the injecting apparatus which serves to remove air from the condenser. It has two impellers and delivers 1300 g.p.m.



DIAGRAMMATIC ARRANGEMENT OF THE HIGH AND LOW PRESSURE SECTIONS OF THE MANNHEIM-RHEINAU STATION

against a head of 154 ft. The cooling water and air ejector pumps are united in one casing which is divided horizontally.

The condensate pump is arranged overhung on the end of the shaft outside the main bearing. This pump withdraws the condensate from the condenser and delivers it to the feedwater tank whence it passes to the intermediate feed pump, D_2. This pump has two stages and delivers 400 g.p.m. against a total head of 130 ft.

MATERIALS ARE commonly measured by volume or by weight. The first is simple and does not vary with location, i.e., a cubic foot is always a cubic foot, whereas, when measuring by weight the method of determining this weight must be considered. Two methods commonly used are by a spring scale or balance scale. By the first, a calibrated spring measures the pull of gravity and as this varies in different parts of the earth, weights determined by this method vary with the location. With the balance scale, the gravity pull on the weights and weighed body varies on both and the error is compensated. The result of weighing a body by a balance scale is known as the mass of the body.

COPPER AND CONSTANTIN thermocouples after calibration can be depended upon within one degree F. up to 600 deg. F. and can be used up to 900 deg. F., although the copper oxidizes rapidly at such high temperatures.

Penstock Valves for Hydroelectric Plants

Location of Valves, Types of Valves for Various Types of Plants and Analysis of Loss of Head in Valves*

IN MANY hydroelectric plants and always in high head installations, there are at least two valves located in a penstock line; one at the upper end as near as possible to the surge chamber or forebay and another just above the hydraulic power unit. In low and medium head installations, but one valve is quite common and that one located at the penstock inlet. With the lower heads, the penstock is generally correspondingly shorter and one means of control is adequate.

Valves are always located in interconnections between penstocks and in the case of a single penstock branching to serve more than one unit, valves should be located in each branch, near the junction, so that trouble with one unit will not make it necessary to shut down the other units. In long penstock lines, valves at intermediate points might be used to sectionalize the lines in case of a break.

Penstock valves are never operated at part opening. They are always either fully open or shut. For this reason, the hydraulic characteristics of the valve at part opening are of no importance, except for the effect that they may have on the smoothness of operation and on the wear of the valve parts during the period of closing or opening. Such valves are rarely operated under flow conditions. They should be designed to give good hydraulic conditions at full opening and to be structurally strong enough not to be damaged in any way by the disturbances due to throttling when they are opened or closed with unequal pressures above and below.

*From a recent report on Penstock Valves of the Hydraulic Power Committee, N. E. L. A.

TABLE I. LOSSES IN LARGE PENSTOCK VALVES AS REPORTED BY MESSRS. GLENFIELD & KENNEDY, LTD.

12 Ft Diameter Butterfly Intake Valve

Flow Cu. Ft per Second	Loss in Feet Head
1483	2.47
1236	1.65
1200	1.56
812	0.72
800	0.70

12 Ft. 6 In. Diameter Butterfly - Bellmouth Intake

Flow Cu. Ft per Second	Loss in Feet Head
1483	0.21
1236	0.147
1200	0.139
812	0.064
800	0.062

12 Ft. x 9 Ft. Johnson-Boving Valve

Flow Cu. Ft. per Second	Loss in Feet Head
1483	1.38
1236	0.97
1200	0.915
812	0.422
800	0.41

Gate valves are in use at both the upper and lower ends of penstocks and in the high head plants of California they are the predominant type. Gate valves 96 in. in diameter are used at the upper end of one plant and operate satisfactorily at a head of about 70 ft. One plant is using 32-in. gate valves of the follower-ring type at the bottom of the penstock under a head of 2381 ft.

A recent design of hydraulically operated gate valve, for which a patent has been issued, has been installed for a head of 2400 ft. and four are operating satisfactorily. Some of the advantages of this valve are: (1) A considerable saving in weight and cost over a comparable gate valve of the usual design; (2) a saving in space requirements; (3) elimination of stuffing boxes, except for the indicator rod.

Butterfly Valves

Butterfly valves at the upper ends of penstocks have been installed with diameters of 11 ft. 6 in. for a head of 140 ft., and 7 ft. 6 in. for a head of 230 ft. These valves have cast steel discs and bodies. Structural steel valves 27 ft. in diameter have been installed in an Eastern plant for about 90 ft. head.

At the lower ends of penstocks, butterfly valves 9 ft. inside diameter are operating under a head of 455 ft., and a 72-in. valve has been operating for over three

TABLE II. TABULATION OF PENSTOCK VALVE DATA BY NEW ENGLAND POWER CO.

	Station No.5		Sherman	Davis	Bridge	Searsburg
	Top	Bottom	Top	Top	Bottom	Bottom
Number of Valves	3	3	1	3	3	1
Nominal Size	84"	78"	168"	96"	84"	78"x56"
General Type	Butter-fly	Butter-fly	Butter-fly	Butter-fly	Butter-fly	Balance Plunger
Type Description	Shaft-Arm	Shaft-Arm	Disc-Arm	Disc-Arm	Shaft-Arm	-
Manufacturer	Allis-Chalmers	Allis-Chalmers	S.M. Smith	Coffin Valve	Allis-Chalmers	W.S.M.
Operating Head	30	230	25	155	390	230
Full Load C.F.S.	320	320	1025	600	600	320
Friction Loss	—	0.33	—	—	0.78	0.70
Velocity thru Nominal Area	8.3	9.6	6.7	12.0	15.6	18.7 Disch.
Velocity head for Nominal Area	—	1.44	—	—	3.78	—
Fric. Hd.+Vel. Hd.	—	0.23	—	—	0.21	—
Operated by	Elec. Motor	Hyd. Cyl.	Elec. Motor	Elec. Motor	Hyd. Cyl.	Hyd. Cyl.
Emergency Closing	Local Control	Local Control	Remote Control	Remote Control	Local Control	Auto-matic
Hand Gear	Yes	No	Yes	Yes	No	No
Source of Hyd. Press.	—	Penstock	—	—	Penstock	Penstock

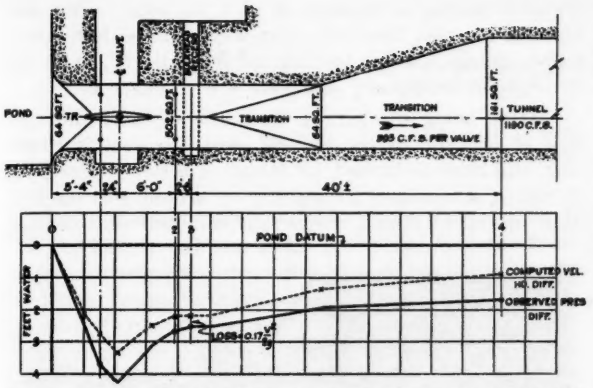


FIG. 1. FRICTION LOSSES IN 96-IN. DOW PIVOT VALVE AND SETTING

years under a head of 930 ft. This is the highest head for any butterfly valve ever used, as far as the committee can ascertain. Manufacturers of butterfly valves state that there is no apparent reason why such valves cannot be built to operate successfully at heads of 1000 ft. or more.

Needle Valves

Needle valves, unbalanced and externally controlled, have been used for many years for the highest heads at which water power has been developed. These valves are regulating valves, directly controlling the jets of impulse wheels, and do not properly come within the scope of this report. Moreover, they are of comparatively small size, the largest being about 11 in. diameter, but the maximum operating velocity is extremely high, as high as 300 ft. per second or more. These valves are mentioned because there is no question as to their reliability, although they are subject to rather rapid wear and consequent leakage, due to the high velocity and their constant operation at full and partial opening.

In one California plant, unbalanced needle valves with external hydraulic cylinder control are used as penstock valves just above the needle nozzles of the power unit.

Use of Balanced Plunger Valves

Balanced plunger valves have been used as shut-off valves adjacent to the power units in a number of California plants. Johnson valves with internal hydraulic control, 72 in. diameter, under 830 ft. head have been used. In these valves, the pressure in the internal hydraulic operating chamber is controlled by a system of external needle valves. Johnson valves with a mechanical control of the internal pressure chambers are in use in sizes up to 24 in. diameter under 2100 ft. head.

Johnson valves 21 ft. in diameter, under 200 ft. head, are in operation in the plant of the Niagara Falls Power Co.

In general, insofar as the head under which the valve is to operate affects the choice of type, both gate valves and balanced plunger valves are in general use for heads over 600 ft. with gate valves predominating, with a tendency in the last two years to use gate valves of the follower ring type for the highest heads. For heads less than 600 ft., butterfly valves seem to be gaining favor, for both the upper and lower positions in penstocks, although there are a number of instances where gate valves without follower rings have been used at the upper ends of penstocks at heads of 200 ft. or less.

Reliable information on which to base comparisons of loss of head through the different types of penstock valves is meager. In gate valves of the follower ring type, in which the follower ring is of the same diameter as the pipe and registers accurately with the pipe when the valve is open, the loss is unquestionably negligible. In gate valves without follower rings, the cavities for the gate seat and guides must create considerable disturbance with consequent hydraulic losses but there are no accurate data available on the amount of these losses.

In straightway plunger valves with carefully designed water passages, the losses should be quite small.

In unbalanced needle valves with external control of the needle, the losses are undoubtedly greater, due to the unavoidable bends in the valve body and to the disturbance caused by the needle stem projecting through the main water passage.

Data on Loss of Head in Valves

Messrs. Glenfield and Kennedy, Ltd., Engineers, Kilmarnock, Scotland, have published some tables giving estimated losses through large diameter butterfly and plunger valves. They do not state how far these estimates are based on actual tests. Table I gives the published data as a matter of interest and to invite comment on their probable degree of accuracy. The estimated losses in the 12 ft. by 9-ft. Johnson-Boving valve when plotted on log paper appear to lie on a line with a slope of 2.

The following report on losses through butterfly valves has been furnished by E. A. Dow for the New England Power Co., and is the most comprehensive study of the subject that has come to the attention of the committee.

The data on head losses given in Table II are from tests in which pressures were observed at several points, as shown on the accompanying diagrams. An additional diagram, Fig. 1, is included showing friction head loss for 96-in. Dow valves which are located in the entrance to a pressure tunnel; while these are not strictly penstock valves, they perform a similar duty, operating under a head of 110 ft.

A feature of interest in connection with the deter-

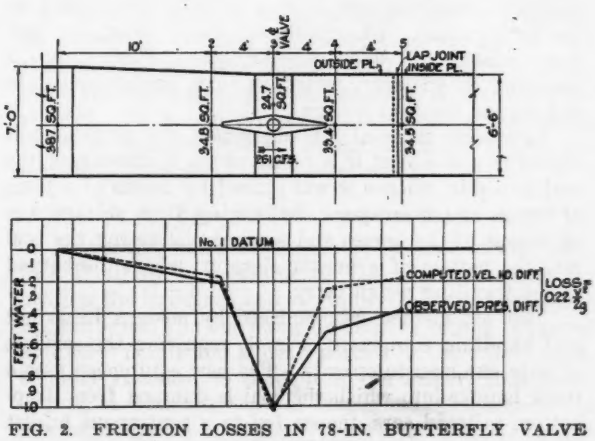


FIG. 2. FRICTION LOSSES IN 78-IN. BUTTERFLY VALVE AND SETTING

mination of head loss through butterfly or other valves is brought out in Fig. 2, which shows an apparent head loss at piezometer connection No. 4 greater than that at connection No. 5 farther downstream. The real loss may be still less than that obtained at point No. 5, but no connection below this point was available.

All tests made demonstrate that the entire loss through the butterfly valve occurs downstream from the center line where the jet is expanding, no observable loss having been found above the center line.

Economy in Coal Handling

SMALL PLANT SAVES BY MODERNIZING STORAGE AND SUPPLY SYSTEM. BY HOWARD E. DIVINE*

NEW INDUSTRIAL plants or power stations are naturally equipped with modern units and latest production methods but large economies can often be effected by introducing them into an old plant.

A small Iowa power company requires an average of 70 t. of coal every 24 hr. for its four 520-hp. boilers and also maintains a storage pile ready for emergency in case of delayed shipments.

Formerly, method of handling coal required the services of five men and a team of horses, which made coal handling costs high. By means of a portable belt conveyor, receiving coal from a railroad car located on the switch track just outside the boiler room, the coal was elevated and delivered through a window into a traveling weigh larry, which, in turn, transferred it to stokers for the four boilers.

In storing the coal for emergency, the portable belt conveyor was moved to a point where it discharged the coal to a pile, whence it was spread by means of a team of horses and a scraper. Reclaiming from storage was by means of the horses and scraper, delivering the coal into the bottom of a bucket elevator, which discharged to the traveling weigh larry.

This old method was replaced by modern Link-Belt coal handling equipment, Fig. 1, requiring the services of only one man to operate. The new equipment uses a track hopper into which the coal is dumped from drop-bottom railroad cars, thence fed to a continuous bucket elevator having a capacity of 25 t. an hour. This discharges the coal through a two-way chute either into a 140-t. storage bin for feeding the weigh larry, or to the ground for emergency storing.

After being discharged from the elevator into the pile at one end of the storage yard, the coal is stored out, and later reclaimed, by means of a Power Hoe, Fig. 2, which is operated to and fro by a double-drum friction, or geared drums, a wire rope and sheaves, a flexible means of storing or reclaiming most bulk materials at a small cost per ton.

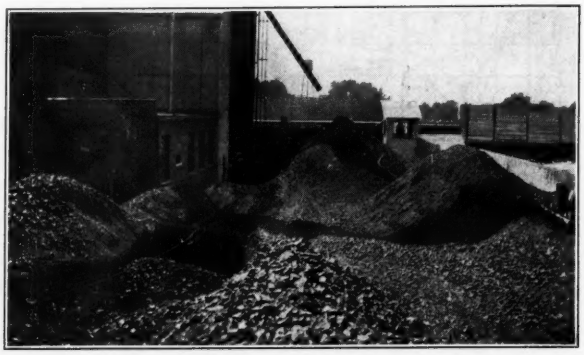


FIG. 2. POWER HOE STORES AND RECLAIMS COAL FROM AND TO BUCKET ELEVATOR

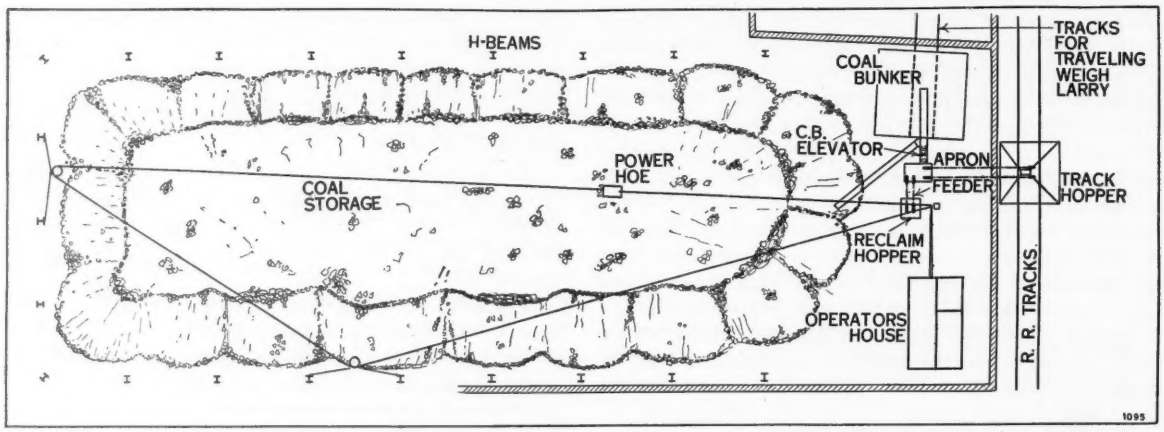


FIG. 1. LAYOUT OF TRACK, ELEVATOR AND STORAGE YARD AT SMALL PLANT

Located in the machinery house where he can see the entire yard, the operator, who is not a skilled mechanic, can operate the hoe and, when not so busied is placing cars over the hopper, or performing the other duties necessary in a coal handling and storage system of this kind.

Considering coal handling equipment cost and the actual saving shown since July, 1928, this modern equipment is returning 37 per cent a year and will pay for itself in less than four years of operation. Furthermore, there will be a saving thereafter of about $26.66 per 100,000 kw-hr. of power generated.

For a plant of its size, this ground storage and reclaiming system is one of the best and proves like many similar installations throughout the United States that mechanical material handling means the saving of dollars.

*Engineer, Link-Belt Co., Chicago, Ill.

Hot Water Storage Saves Exhaust Steam

BESIDES PROVIDING HOT BOILER FEEDWATER, VARIOUS TYPES OF HEATERS SUPPLY GOOD WATER FOR MANY INDUSTRIAL PROCESSES

ONE OF THE OBSTACLES to the conservation of the heat in exhaust steam is the fact that the times when heat or hot water are required do not coincide with the times when exhaust steam is available. Flow of exhaust steam may be continuous and fairly uniform whereas the use of hot water may be occasional. On the other hand, the need of hot water for boiler feeding may be fairly continuous, whereas the supply of exhaust steam is more or less intermittent.

The heating and storing of water offers an efficient and almost generally applicable means of storing heat

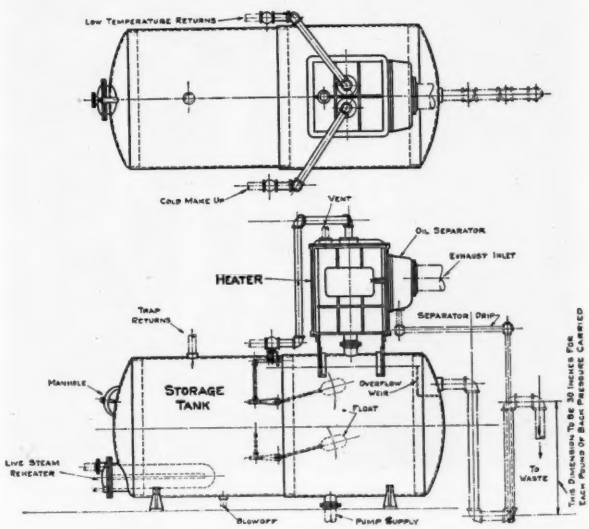


FIG. 1. OPEN HEATER MOUNTED ON STORAGE TANK FOR HEATING UP FROM COLD OR FOR SUPPLEMENTING WITH LIVE STEAM

and the storage type open heater can be used for heating and storing water for any purpose. All of the heat in the steam is utilized and the steam used in heating is condensed and added to the water being heated. Air and gases are driven out of solution in the water, and corrosion of piping, economizers and other apparatus, together with "red water trouble," is thereby avoided. In general, a heater of the storage type can serve as a returns tank, in which to collect the condensate from heating or drying coils, calendering rolls, live steam traps and the like. Where the water contains scale-forming matter or acids which might interfere with industrial uses, as in washing, scouring, dyeing, laundering, provision can also be made for treating the water chemically.

HEATERS MAY STORE HEAT OR WATER OR BOTH

Where the supply of exhaust steam is more or less intermittent, a feedwater heater of the storage type with automatic control valves can be used.

Sometimes the object of storage is to conserve water as well as heat, says The Cochrane Corp., as where condensate is returned from rolls, coils, jackets, live steam traps and so on and raw water is admitted as makeup only. For this purpose the heater is usually fitted with two regulating floats, one at the lower level to admit makeup water when required and one at an upper level to shut off or divert the returns to some other receptacle when the heater storage space is filled.

AUXILIARY LIVE STEAM SUPPLY

Where the exhaust steam supply is not sufficient at all times to heat the water to the desired temperature, live steam can be supplied through a pressure-reducing valve. In order to do this, it may be necessary to carry a back pressure upon the heater to provide a range of pressure within the limits of which the pressure-reducing valve can function. For example, the back-pressure valve may be set to open at 8 lb. gage, and the pressure-reducing valve may be set to open whenever the pressure falls below 5 lb.

Live steam can also be supplemented by placing a perforated pipe or a pipe coil in the bottom of the hot-water storage space of the heater. Another way of attaining the same object is to provide a circulating pump which will draw water from the bottom of the storage space and deliver it again over the trays in the heater. The heating coil or perforated reboiler is useful in assuring removal from the water of air or other dissolved gases.

APPLICATIONS OF HEATERS IN INDUSTRIAL PLANTS

In paper mills, it has been found that pulp can be washed more quickly and thoroughly with hot water than with cold water. Hot water is likewise valuable in the beating engines, the output of which is increased 25 per cent or more over the results obtainable with cold water. Less water is required if it is supplied hot. Inasmuch as the use of hot water, as also the return of condensate from paper machines, is generally more or less irregular, storage is important.

In laundries, bleacheries and dyeing establishments, hot water is required in large quantities at intervals. By chemically treating the water, large savings in soap and washing soda are effected and, by using a filter, annoyances and damage from sediment in the water are avoided. It is also advantageous to use a deaerating heater so that rust will not be formed in the piping nor deposited upon the fabrics handled.

PACKING ESTABLISHMENTS

In packing establishments, the exhaust steam, purified of oil by a separator on the heater, is used for heating the buildings and to supply hot water for washing purposes. The hot-water circulating piping is tapped at several points and a small portion of the water is continually returned to the top of the heater, thus maintaining a constant flow of hot water throughout the hot-water system.

In tanneries and leather factories, hot water is drawn from the heater for all purposes, while the surplus steam is also used for heating buildings and drying leather. A storage-type heater may be located at an elevated point or water may be pumped from the heater to an elevated tank, from which it is drawn to the tanning and liming vats and for washing purposes all through the plant. Usually at each point where water

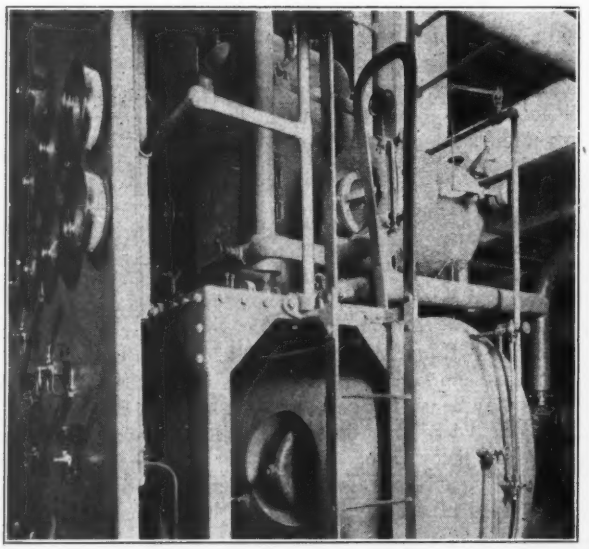


FIG. 2. DEAERATING HEATER WITH STORAGE TANK INSTALLED IN AN OFFICE BUILDING

is used there are both hot and cold water connections, so that the tanner can bring his liquors up to any temperature required, usually about 90 deg. F. Warm water has been found to be especially valuable in washing out acids; less water is required and the work is done more quickly.

Closed Heaters

A storage heater of the closed or surface type comprises a steel tank containing a heating element, which is a bundle of tubes designed to receive live or exhaust steam. In the smaller sizes, the heating element often consists of a bundle of U-shaped tubes attached to a single header, while larger heating elements, of 200 sq. ft. of heating surface or larger, may consist of straight tubes with two headers, one fixed and the other floating. The fixed header is sometimes bolted to the flange of a nozzle welded into one of the heads of the storage tank and the entire heating element can be withdrawn for cleaning or inspection.

Jet Heaters

The jet heater is suited to large capacities, as above 200,000 lb. of water to be heated per hour, as it occupies small space, is low in weight and, for large sizes, is low in cost. It heats the water close to steam temperature and is efficient under heavy load. It can be operated under back pressure or vacuum, changing automatically from one condition to the other according to variations in the flow of feedwater or in the supply of exhaust or bled steam and it is efficient over a wide range of loads.

The jet-type heater is not usually recommended where there are long periods of operation at small fractional loads, where ample head between heater and pump is not available, where the water cannot be supplied under sufficient pressure to give efficient spraying, where complete deaeration is required or for small and moderate capacities.

A jet heater is sometimes operated under vacuum while discharging into a tank or into a heater at higher pressure, in which case it must be fitted with a barometric discharge column. The barometric column is also desirable to prevent vapor binding of the pump where the supply of either water or steam is so variable as to give rise to rapid fluctuations in water temperature.

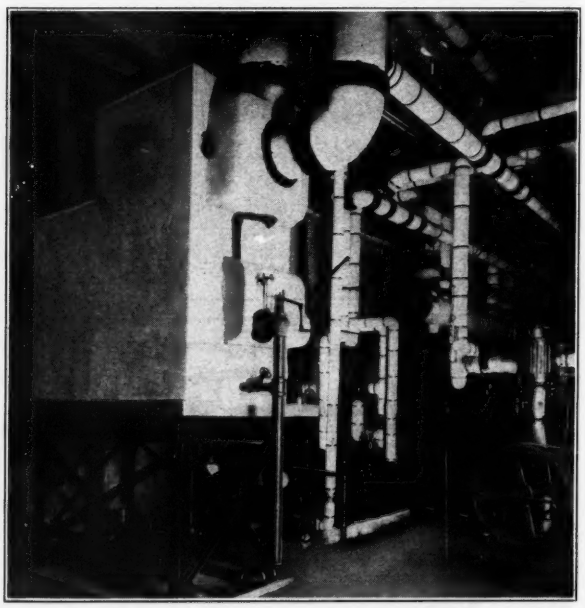


FIG. 3. STORAGE-TYPE OPEN HEATER IN A HOTEL

To provide a certain amount of storage ahead of boiler feed or other pumps, the jet heater is usually arranged to discharge into a capacious barometric column or into a storage tank.

Two general classifications must be considered when dealing with cost of electric service: fixed charges which are the same regardless of the output of the station, and operating expenses which vary with the volume of business even though certain of these expenses in a given plant are constant. Fixed charges include: interest on the investment, taxes and depreciation, while operating expenses include fuel, labor, rent, advertising, maintenance, meter reading and collecting bills, and supervising overhead.

One pound of carbon burned to CO requires 1 1/3 lb. of oxygen and liberates 4500 B.t.u. If burned to CO_2 2 2/3 lb. of oygen will be required and 14,600 B.t.u. will be liberated. Similarly one pound of hydrogen requires eight pounds of oxygen and liberates 62,000 B.t.u. while one pound of sulphur requires one pound of oxygen and liberates 4000 B.t.u. The relative value of a pound of oxygen burned with carbon, hydrogen and sulphur will be 1825, 7750 and 4000 B.t.u. respectively.

Water Slugs Cause Pump Damage

IT IS COMMONLY supposed that water will not be lifted by suction in a pipe over about 33 ft. but, if there is enough water to fill the pipe cross-section entirely, water will be carried over in slugs just as it is in an air lift.

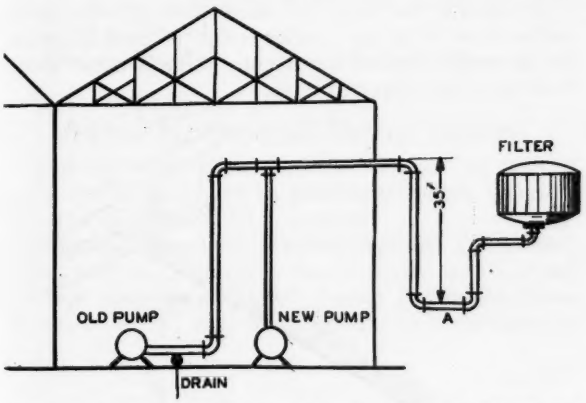


FIG. 1. DIAGRAMMATIC REPRESENTATION OF PUMP INSTALLATION SHOWING PIPING LOOP ARRANGED TO AVOID WATER PASSING INTO VACUUM PUMP

Some time ago, a new vacuum pump was installed on a filter because the steam-driven pump was old and all of the steam-driven machines in our plant were being replaced by motor-driven units as soon as they became obsolete. The pump was installed about as shown in the sketch with a vertical rise of 35 ft. so that no water would be drawn over. Early one morning, shortly before the day shift man came on and the new pump had been started, the crankpin broke. As the old pump had run for years without giving trouble, the manufacturer felt that water might have caused the trouble, so he supplied a new crankpin, which was installed and the pump put in service again.

In about two weeks, the same thing happened again, except that this time the damage was more serious, the head being knocked off the cylinder and the crankpin and connecting rod badly bent. This time, it appeared that the trouble was undoubtedly due to water, as no evidence could be found of a bolt or other foreign material in the cylinder and all the valves were intact.

Evidently the first accident had happened to the crank end. Either because the head was stronger, the slug of water smaller or the head was partially supported by the frame, the cylinder head was not blown from the cylinder and, as the connecting rod was in tension, the crankpin, being the weakest part, gave way, preventing any further damage. In the second accident, however, the slug evidently entered the head end and must have been of considerable size to bend the connecting rod as badly as it did.

After an investigation, it was decided that the slugs of water came, not from condensation, but over the pipe loop which ran as shown in Fig. 1. A considerable run of horizontal pipe served the suction side of the old pump but the new pump was supplied with a short nipple only. Evidently, the receiver action of the horizontal pipe was sufficient to protect the old pump while on the new one that was lacking. Each line was provided with a drain for removing condensate.

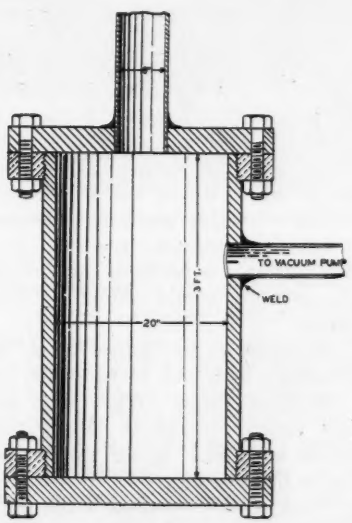


FIG. 2. RECEIVER, MADE OF PIPING, TAKES UP PULSATIONS

A receiver, Fig. 2, made from some old pipe, remedied the situation. That slugs of water were pulled over was shown by filling the pipe at A with water and starting the vacuum pump. Evidently the water in the pipe would be drawn up until a height was reached at which the column would break. The column would then be pulled up again and this process repeated several times, causing surging in the pipe until a slug of con-

siderable size would be drawn over. A drain was also provided at A, Fig. 1, so as doubly to safeguard the vacuum-pump cylinders.

Brooklyn, N. Y. F. PAUL.

Exhaust Steam Requirements and Power Generation

IS NOT THE method adopted by most operators of power plants running noncondensing engines and using the exhaust steam for heating for determining the proper time to cease generating power and purchasing it, incorrect?

Suppose that we have a 500-kw. generating unit that can just supply the requirements for exhaust steam when operating at 400 kw., is it economical to start purchasing power above that load at which the engine will just avoid exhausting steam to the atmosphere? Many men consider this the proper procedure and will allow no exhaust steam to escape, if it is possible to avoid so doing.

On the contrary, many plants continue, with profit, to generate power considerably beyond this point of no atmospheric exhaust. The idea that an engine is a reducing valve has been carried too far. For instance, where this opinion prevails, the engineer will allow the engines to leak at times because he thinks it makes no material difference, since the mill uses the steam anyway, whereas, if the engine is in first class condition, considerably more power could be generated by it without added expenditure of steam. Added power generated at no cost thus means less power purchased at some cost.

Suppose that coal, for our 500-kw. plant, can be purchased at $5 a ton and that 4 lb. per kw-hr. are used. Also, assume that electric current can be purchased at $0.02 per kw-hr. Under these conditions, our engine will require 1600 lb. of coal an hour and will generate 400 kw-hr. at a coal cost of $4. The mill will buy the 100 kw-hr. which could be generated at a coal cost of $1, but the purchased cost will be $2. Extra labor cost has not been considered but the rise in maintenance cost certainly would not offset this difference indicated above.

Doesn't it appear to be foolish to pay $2 for what might be produced at a cost of $1? Yet many plants are doing that very thing. Why be so particular to generate just enough power to supply the necessary steam when the additional power may be generated in most cases at so little cost?

Another phase of this question is the faulty attitude taken by many engineers that it does not pay to install a high class engine, if all of the exhaust steam can be used. They say, "Why spend a lot of money for an engine to economize in the use of steam when all of the exhaust will be used anyway?" So they install the cheapest engine they can buy, which probably is uneconomical in the use of steam. Such an installation would be justifiable, if the demand for power never increased, but this is seldom the case; more often the increase is rapid and a time is reached when the exhaust steam produced is more than can be utilized.

In a certain institution, which has a heavy demand for current, hot water, steam for heating at low pressure and steam at medium pressures for laundry and kitchen purposes are required. High-speed engines are used and much exhaust steam is wasted during the warmer weather. Power and steam demands coincide quite well but large amounts of power are purchased that could be generated at less than purchase cost, if a better type of engine had been selected. It so happens that this plant is located near places where most steam demand exists so that installation of a bleeder turbine might be advisable and use of an absorption ice plant instead of one of the compression type might be desirable. But this company continues to buy power simply because it got started wrong and now thinks that money cannot be spent to rectify this condition.

Many factors have a bearing on this question and as the solutions have varied so much, it would be interesting to hear of the experiences of other engineers and to learn the methods others have used for solving this problem.

Turner's Falls, Mass. WILLIAM W. WHITE.

Boiler Cleaning Devices Effective

REMOVING THE SCALE and mud which collects on the bottom sheet of an h.r.t. boiler is not the most enjoyable job on earth when one has to enter the boiler and scrape it out as I was educated to do.

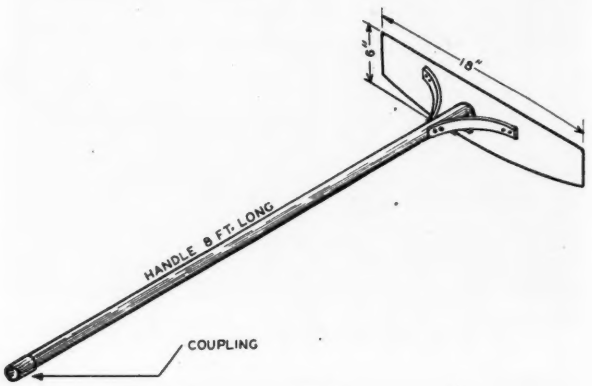


FIG. 1

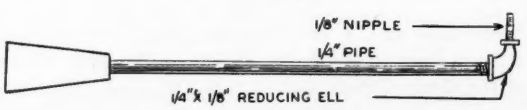


FIG. 2

FIG. 1. SIMPLY CONSTRUCTED HOE MAKES CONVENIENT SCRAPING TOOL FOR REMOVING BOILER DEPOSITS
FIG. 2. SMALL PIPE AND FITTINGS MAKE EXCELLENT TOOL FOR SCRAPING BOILER TUBES

In order to avoid this disagreeable method, I made a light hoe of sheet metal having one edge cut to the radius of the boiler and supplied with an 8-ft. handle, of ¾-in. pipe as shown in Fig. 1.

One end of this pipe was flattened and bent at right angles. Two holes were drilled through the bent end, two in the center of the blade and the handle was fastened on with rivets. Two light braces were attached from the handle to stiffen the blade. The end of the handle is threaded and a coupling screwed on so that lengths of pipe may be added or removed as desired.

By means of this scraper I have cleaned, from the outside, a boiler that had been operated for a long

period without ever having been cleaned. A couple of wheelbarrowfuls of scale were removed.

This hoe has saved me a lot of skinned elbows and wettings.

Another boiler cleaning device which I have found handy consists of a discarded nozzle, threaded to fit a regular male coupling on a 1-in. water end. The small end is tapped for ¼-in. pipe, which is cut to any length desired and to which is attached a ¼ by ⅛-in. reducing elbow into which is screwed a ⅛-in. short nipple as shown in Fig. 2. This places the nipple at right angles to the ¼-in. pipe. By running the pipe down between the tubes and turning it so that the ⅛-in. nipple points crosswise of the boiler, you can draw the device along the tubes and scrape mud and scale from any part of the tubes, including parts that cannot be reached with an ordinary straight nozzle.

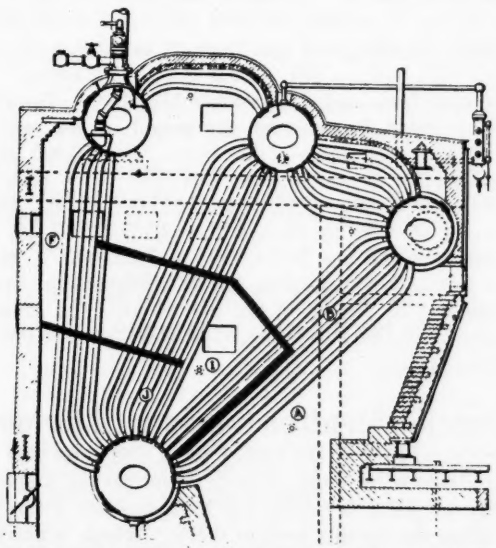
By using a 20-ft. length of ¼-in. pipe, I have cleaned out a 72-in. by 18-ft. h.r.t. boiler through the front manhole so thoroughly that only 11 lb. of scale was removed afterward, when I tested the effectiveness of the system by washing the tubes from the top by going in on top of the tubes.

Minneapolis, Minn. FRED S. RUTLEDGE.

Avoid Horizontal Boiler Baffles

HORIZONTAL SHELVES are formed when the type of baffle illustrated is used in water-tube boilers, therefore this type of baffle should be avoided.

Although these baffles are not perfectly flat or horizontal, they are sufficiently flat to permit soot and ash to lodge upon them and this deposit will not be blown off either by the gas in its natural flow through the



HORIZONTAL BAFFLES FORM SHELVES FOR COLLECTING SOOT AND ASH

boiler or by the steam through soot blower nozzles. Baffles should always be installed steep enough so that soot and ash will not settle and remain upon them.

I am a believer in the cross baffling of bent tube boilers, wherever this is possible but the old parallel method of baffling is better than the one illustrated because it does not permit ash and soot to pile up and cut out a large percentage of the boiler's most valuable heating surface.

Newark, N. J. W. F. SCHAPHORST.

Repair of Concrete Poles in Place

IN THE CITY of Hamilton, Canada, the electric transmission wires serving private consumers are carried on reinforced concrete poles, many of which became cracked and chipped, especially from frost in the winter, thus exposing the steel reinforcing rods.

DAMAGED CONCRETE POLES REPAIRED IN PLACE

Formerly it was customary to replace the poles when they had become damaged but a method has been developed by the Hydro-Electric Power System of the city by which thousands of these poles have been restored to a condition even better than the original. A scaffolding is erected around the pole to be restored, all loose portions are hacked off and a specially prepared cement binder is thickly brushed on the damaged part. Before this has had time to dry, a rich, quick-drying cement mortar is plastered on with a trowel. Then the whole is painted with liquid cement.

Hamilton, Canada. JOHN E. MASON.

ENGINEERS must keep up with power plant advances or drop entirely out of the steadily advancing stream of successful engineers. An executive cannot be expected to give serious consideration to an engineer who follows practices of a generation ago. The successful engineer must do more than be familiar with modern equipment and practice; he must be able to think clearly, analyze a situation and separate the good from the bad.

A KILOWATT of electricity is equivalent to 3412 B.t.u. or 1.43 hp.

Smoke Abatement

WE ARE HAVING considerable trouble with smoke at the heating plant of our university where two 72-in. by 16-ft. h.r.t. boilers are installed and would appreciate information regarding overcoming the smoke nuisance and specifically regarding the use of steam jets for that purpose. H. V. F.

A. The whole problem of smoke abatement is so complex and there are so many factors involved that it would be unwise to attempt an adequate solution of any one case without a careful study. There are, however, a few simple facts concerning smoke abatement that, if thoroughly understood, will help you to solve your own problem.

Smoke prevention is accomplished when we secure perfect combustion, therefore the gases as well as the solid combustible must be consumed following the laws of combustion. These laws may be stated as follows: (1) adequate supply of air; (2) proper mixture of the combustible (gas or solid material) and air; (3) sufficient temperature to cause chemical union between combustible and supporter (air) and (4) this temperature must be maintained until combustion is complete.

Adequate supply of air means sufficient, but not too much, excess air. If the fuel is highly volatile, it is quite probable that you will need an over-fire air supply. An article on "Over-Fire Supplementary Air Introduction" by Grunert published on page 245 of the February 15, 1927 issue explains in detail how to admit this air and shows the advantage of so doing. In hand stoking, careful firing of small amounts of fuel at a time and leaving the fire door ajar for a short time just after firing fresh coal, will usually suffice.

Proper mixture is aided by sufficient size of combustion space. Frequently boilers are set too low. Impinging streams of air aid in mixing as well as in supply of over fire air. Steam jets aid in mixing but their use is usually expensive. The writer knows of cases where 10 per cent of all the steam generated was used for steam jets. Besides mixing, steam jets add nothing to abating smoke although steam ejected from the stack with smoke will bleach the smoke making it appear less dense.

Baffles in the furnace aid in mixing and also in supplying heat to the gases during the distillation process. If the gases are cooled, as by contact with the tubes, before they are completely consumed, smoke will result, the hydro-carbons of the fuel being separated out from the gases and combustible gases are passed out of the stack unburned. White flames should not strike cooling parts. Where flame exists, there is incandescence and in this case combustion is not complete. Many boilers in which long flame coals are used have been so set that white flames reach the tubes. In this case you will always make smoke. Sometimes a boiler is driven so much above its rated capacity that gases are formed faster than they can be consumed.

Smoke coming from stationary boilers as operated normally is not composed of carbon particles broken from the fuel but of hydro-carbon particles distilled from improperly burned gases. The gases, therefore, should be burned before they form smoke. After smoke has been formed, it cannot be consumed easily.

Your best source of information on combustion, fuels and smoke abatement is the Bureau of Mines, Washington, D. C. Write them for a list of bulletins published on these subjects then send as directed for those bulletins that interest you.

Calculation of Refrigeration for Cooling Fish

HOW MUCH refrigeration is needed to freeze 50,000 lb. of white fish, which are received for storage at 60 deg. F., and frozen to a temp. of 10 deg. above zero in 48 hr. time? E. J. S.

A. Specific heat of fish averages 0.82 above freezing and 0.43 below freezing. Their average latent heat is 110 B.t.u. per lb. To lower one pound of fish from 60 to 32 deg. F. will require $0.82\ (60 - 32) = 23$ B.t.u. To lower one pound of fish from 32 to 10 deg. F. will require $0.43\ (32 - 10) = 9.5$ B.t.u. To remove the latent heat from each lb. requires 110 B.t.u. The total heat that must be removed per pound of fish will be then $23 + 9.5 + 110 = 142.5$ B.t.u. For 50,000 lb. of white fish the amount of heat required to be removed will be then $50{,}000 \times 142.5 = 7{,}125{,}000$ B.t.u. Since 48 hr. is allowed to remove this 7,125,000 B.t.u. the removal required per 24 hr. will be $7{,}125{,}000 \times 24 \div 48 = 3{,}562{,}500$ B.t.u. One ton of refrigeration equals the removal of 288,000 B.t.u. per 24 hr. The tonnage required will be, therefore, $3{,}562{,}500 \div 288{,}000 = 12.38$ t.

Specific Heat of Calcium Chloride

ON PAGE 1319 of the Dec. 1 issue, you state that the specific heat of calcium chloride brine having a specific gravity of 1.218 is 0.7025. I have a chart before me that gives the specific heat as 0.799. Which is correct? B. K. M.

A. Some of the charts which have been copied into present day textbooks give 0.799 as the specific heat of calcium chloride having a specific gravity of 1.218 but these values were obtained probably for 73 per cent calcium chloride rather than pure calcium chloride.

If the tables published in the A. S. R. E. Data Book, Circular No. 9, are consulted or those in Jessup's article on "Properties of Refrigerating Brines" published in

the December, 1925 issue of Refrigeration Engineering are examined, it will be seen that pure calcium chloride brine of a specific gravity of 1.212 is a 23 per cent brine and has the following specific heats:

Temperature in deg. F.....	86	68	50	32
Corresponding specific heat..	0.721	0.715	0.709	0.702

On page 122 of Woolrich's Handbook, which is published by the D. Van Nostrand Co., there is a calcium chloride brine table which was originally published by York. This gives the specific heat at 0.7076 for 1.212 specific-gravity brine and 0.6979 for 1.223 specific-gravity brine. By interpolation of these different values, it will be found that the value 0.7025 at 32 deg. will be as nearly correct as modern practice will require.

Calculation of Refrigeration for Milk Cooling

How large must be refrigerating machine be in a dairy which has to cool 600 gal. of milk in 3 hr. from 80 to 40 deg. if brine tank storage is used and the refrigerating plant runs 9 hr. per day? The radiation loss is neglected. Specific gravity of milk is 1.03.

E. J. S.

A. 600 gal. of milk.

One gal. of water weighs 8.337 lb.

Milk with a specific gravity of 1.03 will weigh, therefore, $1.03 \times 8.337 = 8.60$ lb.

Total weight of 600 gal. $= 600 \times 8600 = 5160$ lb.

The specific heat of milk is 0.9.

Since the milk must be lowered from 80 to 40 deg. F., or 40 deg. F. and each pound has a specific heat of 0.9, then the total heat to be removed will be

$5160 \times 0.9 \times 40 = 185{,}760$ B.t.u.

But by using the brine tank, this is distributed over 9 hr.

The heat that must be removed from the brine tank per hour will be 1/9 of 185,760 or 20,640 B.t.u.

12,000 B.t.u. per hr. = 1 t. of refrigeration.
To remove 20,640 B.t.u. per hr. will require
$20{,}640 \div 12{,}000 = 1.72$ t. of refrigeration.

Brine Required for Given Refrigerating Effect

If a ton of ice requires 320 B.t.u. per min., how much brine must be pumped to make 20 t. of ice in a can system plant in which brine is pumped to the ice-making tank from a cooler located outside the tank. Specific heat of brine is 0.808. Weight of brine is 75 lb. per cu. ft. Brine enters freezing tank at 12 deg. and leaves at 14 deg.

E. J. S.

A. Sp. heat of brine = 0.808

20 t. will require $20 \times 320 = 6400$ B.t.u. per min.
Brine enters at 12 deg. leaves at 14 deg. F.

Heat carried by each pound $= 0.808 \times 2 = 1.616$ B.t.u.

$6400 \div 1.616 = 3960$ lb. per min.
$3960 \div 75 = 52.7$ cu. ft. per min. for 24 hr.
$52.7 \times 60 \times 24 = 76{,}000$ cu. ft. per 24 hr.

Magnesium Sulphate as a Boiler Water Treatment

Do you consider it good practice to use epsom salts with sodium aluminate? What is its action in that connection?

C. J. M.

A. Epsom salts is a trade name for a form of magnesium sulphate ($Mg\ SO_4\ 7\ H_2\ O$). Of substances that cause hardness in water, magnesium sulphate is one of the most difficult to remove but, if the boiler water to be treated by coagulation is very low in magnesium, sodium aluminate alone does not effect coagulation hence a sufficient amount of epsom salts in conjunction with lime and soda ash is added externally to produce proper action. This combination, which is similar to the double coagulation method, wherein sodium aluminate and aluminum sulphate are sometimes used, has proved satisfactory when the proper proportions of the different ingredients are used.

It is believed that the use of magnesium sulphate in conjunction with sodium aluminate for internal treatment serves not only to set up more effective coagulation but also to act as a silica scale preventive, by the formation of an insoluble magnesium-aluminate-silicate. Investigation of the action of the combination treatment mentioned is in development but has not progressed far enough to prove definitely correctness of the above theory.

Factor of Evaporation and Boiler Horsepower

What is the factor of evaporation and what the boiler horsepower of a boiler operating at 120 lb. press. abs. with feedwater at 160 deg. and having a total evaporation of 8760 lb. per hr.?

V. P. K.

A. The factor of evaporation of a boiler is

$f = (H - h) \div 970.4$

where H = total heat in 1 lb. of steam. (At boiler pressure 120 lb. abs. and corresponding steam temperature = 1189.6 B.t.u.)

h = heat of the liquid. (At feed temperature, 160 deg. = 127.86 B.t.u.)

970.4 = latent heat of evaporation of 1 lb. of steam at 212 deg.

H and h are obtained from steam tables. Therefore,
$f = (1189.6 - 127.86) \div 970.4 = 1.09$

Total evaporation being 8760 lb., the equivalent evaporation will be $8760 \times 1.09 = 9548.4$ lb. steam and the horsepower of the boiler will then be $9548.4 \div 34.5 = 276.8$ hp.

For low heads and where accuracy is desired for water level measurements, a hook gage should be used. This consists of a rod arranged to move vertically, on the lower end is a sharp pointed hook and on the upper end a slow motion screw to control the vertical movement. A vernier attachment to read to one thousandths of a foot is commonly used. In using, the hook is lowered beneath the surface of the water and, raised slowly until it is just visible. It should then be lowered until the slight elevation caused by the surface tension of the water disappears. This is then the water level and the vernier should be read. When raising the hook, the surface film should not be broken.

Editorial Comment

What and How in Operation

To draw an analogy between the operation of a power plant and the workings of an orchestra of many pieces is trite but the comparison is apt except that failures in harmony of the musical instruments result only in unpleasant sounds while failures in operation of equipment in power plants may result in accidents disastrous to property and life. As a person watches the various sections of an orchestra, he marvels at the unity of motion, tone and pitch produced by the individual players. Even the slightest deviation by one player would cause consternation in the entire orchestra. Each player and each instrument must respond instantly to the directions of the leader.

In the power plant, a similar harmony of operation is essential to efficient results. It is not sufficient that the outgoing line be kept charged continuously with electricity. Voltage and frequency must be maintained within extremely narrow limits of variation. Economy of operation must meet the requirements of the plant owners. To meet all these requirements, the attendants must work in harmony and synchronism throughout the entire plant, following, without deviation, instructions of the men in authority.

This necessity has, in many plants, led to printed instructions detailing what to do under various conditions and how to do it. Such instructions must of necessity be clear, concise and complete, covering each piece of equipment in the plant and all conceivable conditions, leaving to the executive head of the plant the necessity of giving instructions covering only unforeseen conditions.

As a rule, instruction covering the operation and maintenance of separate equipment are secured from the manufacturers; local conditions, however, necessitate modifications which must be worked out by the engineer in charge of the plant. This plan has been carefully followed in Cahokia and we are privileged in this issue to publish the instructions on the operation of pulverized fuel equipment. Thus, in regular operation, no matter who does the starting, stopping, inspection or cleaning of equipment, the procedure is always the same, if the printed instructions are followed. Likewise, certain emergencies may be taken care of according to printed rules, thus averting errors of judgment at a time when doing the wrong thing may cause great damage.

Codes for the operation of power plants are compilations of answers to the questions what? and how? applied to each and every piece of equipment in the plant. To insure that the answers are the same, we know of no better way than to have the instructions printed and learned thoroughly by those who will be called upon to do the work.

If D.C. Auxiliaries and Standardized Designs Do This, Perhaps We Should Have More of Them

As power plant practice has advanced, direct current auxiliaries have become less popular and the tendency toward large units and high voltages more pronounced. Many have wondered at the persistence with which the Detroit Edison Co. hold to direct-current auxiliaries and the loyalty with which it stands by what Mr. Parker has termed 50,000-kw. "long waisted darlings."

No one would suggest that this company is unprogressive, nevertheless its practice has caused some wonderment, if not criticism, so that some recent remarks of Mr. Dow are of unusual interest. Speaking before the A.I.E.E. and Detroit Engineering Society on questions most frequently asked the engineering department he said:

"Of our electrical eccentricities, most prominent is a habit, now quite well established, of putting up a separate plant in those big power houses for the purpose of running the auxiliaries and having that auxiliary plant a 250-v., direct-current plant. I have been argued with many times about the direct-current plant. I have been told that it is all wrong, that I was wasting energy, that I was wasting money. I have always answered that the people that have to live with those plants like them.

"They are large enough to be economical. When you are working with sets that originally were of 2500 kw.—later sets were 4000 kw. rating capable of steady operation at 6000 kw.—when you are working with such sets running with condensers or running them in such a manner that any steam bled from them is used properly—when you are running such sets in that way—the actual economy can be quite high.

"You have an entirely independent plant of a peculiarly reliable character. I have known some of the best plants in the country to be shut down because of trouble with auxiliaries. We have had no trouble with our direct-current auxiliary plants. Nor are we likely to have trouble. The generators are big and slow. The motors have the best possible speed control and high efficiency at low loads and average loads. The busbars are run around the basement quite casually. The copper bars are supported by albirene cleats and insulated with three turns of sail cloth sewed on.

"Generators are electrically central as to the auxiliaries, so that transmission losses are low. Starting and safety gear is of the simplest. To take a generator off, all that is required is to shut the throttle. A reliable reverse current relay does the rest. Starting an auxiliary generator is just as simple. A balanced voltage relay puts it into service. Any part of the auxiliary system can be handled while it is hot, which is more than can be said for any alternating-current method.

"As to economy—our stations don't do so badly in total economy.

"In the twelve months ending October 31, 1929, the actual net output of the power houses to transmission lines and distribution lines was 2,637,753,600 kw-hr. For the whole system, our British thermal units per net kilowatt-hour for the whole twelve months was 16,840.

"That figure compares somewhat unfavorably, of course, with the occasional record run, but I do not know of any outfit in the country that is getting out any such amount of current with that net efficiency. That is to say, I do not know of any outfit in this country or elsewhere with such an output which is approximating that efficiency for a complete system. There are special cases where the figure is bettered. In each such case, when you come to analyze it, there is good reason why it should be so. Our load factor tends to fall between 50 and 54 per cent.

"If that efficiency is not the best, it is at least far up in its class. That it might be better is quite true, because here is the old Delray plant that had an output of 298 million kilowatt-hours at 22,000 B.t.u.'s per kilowatt-hour. Here is Connors Creek, the efficiency of which has never varied much, with 755 million kilowatt-hours' output at 19,290 B.t.u.'s Marysville drops to 15,430 with 417 million output. Trenton Channel, which has furnished over 40 per cent of the entire output, has a record for twelve months of 14,390 B.t.u."

As Mr. Dow says, there may be other systems that are doing better, and there may be isolated cases where the best performance at Trenton Channel is bettered but if so, they are hiding their light under a bushel. Until we hear more from those who say they are leading the parade, it might be well to give a little thought and perhaps serious consideration to the very evident economy of conservative progressiveness practiced by Mr. Dow and his associates.

Investigate Accidents

Accidents may occur in any situation where power is either generated or used. Accident abatement and in many cases, prevention of recurrence of an accident, may be accomplished by proper analysis of the conditions which brought about a specific accident. Such analyses should determine not only the immediate or apparent cause but also the underlying and contributing causes. Today, many organizations consider essential an investigation of at least each serious accident, in order to obtain this information.

Not only is it possible to obtain the facts concerning basic causes of accidents, in this way, but such investigation also serves to emphasize the seriousness of personal injuries and to convince employes of the importance attached to accident prevention work by the management. Because of their strong appeal, recourse is generally made to the original instincts in order to arouse one or more of them. An illustration in the company magazine, showing a picture of one of the employes wearing goggles, one lens of which has been badly cracked by a flying chip is a potent reminder to other employes to wear goggles which are provided for them, where danger to the eyes exists.

Accident investigations are frequently conducted by the safety director accompanied by the supervisor in charge of the injured employe or of the department in which the accident occurred. In other cases, they are made by the safety director, acting with the regular safety committee. The safety director generally maintains a record of all investigations, sends a report of them to the management or department head, supervises the correction of unsafe conditions or practices and prepares copy for publication in the company magazine or for the bulletin board.

In power plants where no provision is usually made for a safety director, accident investigation and report should nevertheless be made and records kept for future reference. Much loss from this source may thus be avoided.

A Persevering Motor

Wonders will never cease. We have become accustomed to the marvels of radio, to the novelty of talking pictures and we scan, without surprise or emotion, a news item of another 75-story skyscraper to be erected. In the electrical and mechanical fields, developments succeed each other with such rapidity as to make it impossible to have detailed knowledge of them all. We have electric motors for every conceivable purpose and of all sizes from the tiniest clock motor to units of tens of thousands of kilowatts capacity.

But what would you say, if somebody told you about a motor which, attempting to pull a load but failing, deliberately begins to jerk, first gently and then harder and harder, until finally it succeeds in turning over the load? You would, no doubt, assume a skeptical attitude. Well, the Westinghouse Co. has developed just such a motor.

This motor, when it finds that it cannot start a load, tries again and again, each time a little harder, just as a human being would. Of course, electric motors always do their best and, if the fuses don't blow, they will die trying, but since a poor little motor often has to work on a comparatively low capacity fuse, there is a limit to what they can do before the fuse blows. If they could only overcome the initial starting friction they would have no trouble.

This new motor, which is a small one-quarter horsepower unit, goes about its job differently; in fact it almost thinks. If, in trying to start an air compressor, for instance, it finds that it cannot get it over center, does it push and push until finally it dies of overwork? Not this motor. It stops to consider and, having done so, delivers the load a sharp blow. This may start things moving but, if it doesn't, the motor pauses and then delivers a harder blow until finally, Presto! the load succumbs. Once under way things run smoothly.

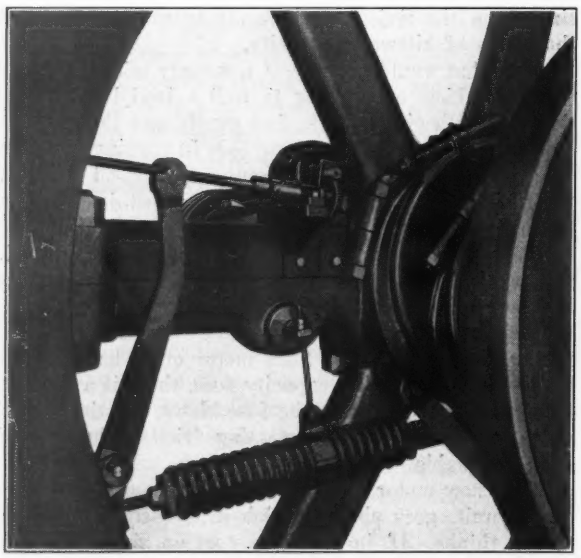
We might point out that some human beings could take a lesson from this motor but, to set a machine up as an example for human action, really is carrying things a little far—anyway the idea is fairly obvious.

This persevering motor, which, by the way, has only four moving parts, is an example of the high engineering skill often required of designers. If this quarter horsepower motor had been ten thousand times larger, it would have been aided in its emergency by skilled human attention, by specially engineered power supply and by intricate automatic controls. But this motor, which will never feel the touch of a skilled hand from the day it is installed to the day it is finished, can have none of these things. So the designers built a set of brains right in the motor itself.

Power Plant Engineering Developments and News

Motor-Controlled Steam Engine Governor

TO FACILITATE the synchronizing of two or more engine generator units, the Mattoon Engine Works, Mattoon, Ill., successor to the Chuse Engine & Manufacturing Co., has developed an electrically operated



MOTOR CONTROLS TENSION OF GOVERNOR SPRING, THUS CHANGING ENGINE SPEED

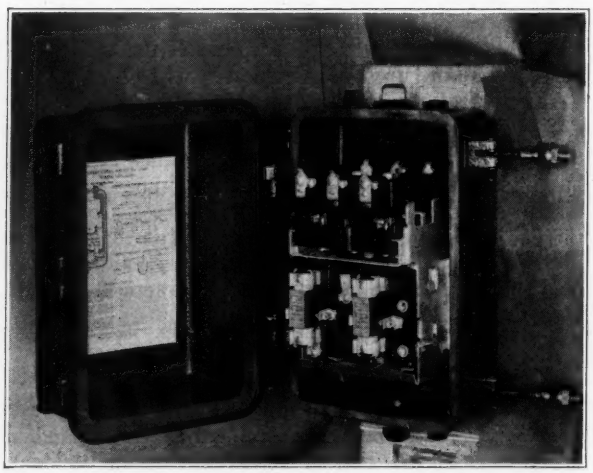
and controlled governor device. This consists of a reversible type motor mounted within the flywheel; through a series of screws, gears, and lever, this motor is designed to change the tension of the main spring of the governor, thereby changing the speed of the engine. The motor is controlled by a double-throw switch mounted on the main switchboard.

By means of this device, it is stated, the speed of the engine may be increased or decreased five per cent above and five per cent below normal speed without impairing the speed regulation of the engine. The change in speed is made slowly and uniformly, it is claimed.

This device may be applied to all Chuse Uniflow and Corliss engines using the centrifugal-inertia type of governor. No changes are required to be made to the present governor other than omitting the spring screw bracket in the rim of the wheel, therefore it can be used on engines now in operation.

Gas-Tight Enclosures for Condit Air Motor Starters

CONDIT ELECTRICAL Mfg. Corporation, Boston, Mass., announces the development of a gas-tight enclosing case for their cross-the-line air motor starters, types A-20 and A-30. The new enclosing case is of exceptionally strong cast iron construction. A gasket



NEW ENCLOSING CASE FOR AIR MOTOR STARTERS

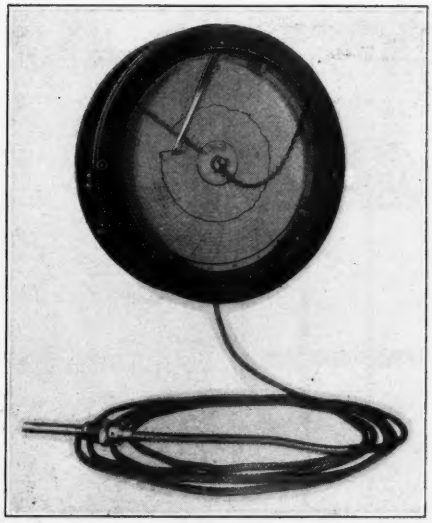
is provided between the cover and the case. Four heavy eye-bolts and nuts hold the cover tight. The cover is hinged and provision is made for padlocking it closed. Provision is also made for conduit connections at top and bottom.

In addition to being gas-tight, the enclosing case is dust-tight and weatherproof.

The new enclosing case is to be offered for installation in mines, woodworking plants, cement mills, flour mills, pulverizing plants, chemical plants and other industries where a large amount of dust or gas may interfere with the efficient operation of a standard starter.

Motoco Recording Thermometer

NEW RECORDING thermometer, designed for charting temperatures from minus 40 to plus 750 deg. F., has been perfected by the Moto Meter Gauge & Equipment Corp. of Long Island City, N. Y. The new instrument is known as the Model 1000 Motoco recording thermometer. The instrument consists of a dust-, fume-



MOTOCO RECORDING THERMOMETER FOR —40 TO +750 DEG. F.

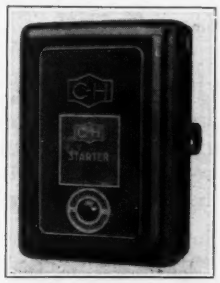
and moisture-proof housing which encloses the working parts. The element is composed of a bulb, capillary tube and Bourdon tube, filled solidly with a special liquid made to have an equal coefficient of expansion over the entire scale range. When the bulb is subjected to heat or cold, the liquid content therein expands or contracts and this action is transmitted through the capillary tubing to the Bourdon tube, causing the latter to wind or unwind and move a pen across the face of a chart actuated by a 24- or a 7-hr. clock mechanism.

The ratio between the pressure of the liquid and the movement of the pen is one to one in order to eliminate levers, hair springs, screws, gears and other delicate parts. A compensating spring is used to take up any difference between the bulb and room temperature and automatically to reset the pen at the point on the chart corresponding with the bulb temperature.

D. C. Counter E. M. F. Automatic Starter

ANNOUNCEMENT was made recently by Cutler-Hammer, Inc., of Milwaukee, Wisc., of a new counter e.m.f. type automatic starter, for small d.c. motors on general applications. This new starter incorporates a number of new and important features such as: small size, reduced voltage starting, thermal overload protection, low voltage protection and renewable silver contacts. It is rated up to 2 hp., 115 or 230 v. and is designed especially for direct-current service; the renewable silver contacts insure long life. Each starter is supplied with a separate pushbutton master switch providing three-wire remote control. Two-wire control can be furnished if desired. The starters consist of a main line contactor, an accelerating contactor, an armature resistor, and the thermal overload relays. On depressing the "start" button of the master switch, the main line contactor connects the motor to the line through the armature resistor. As the motor accelerates to the proper point, the counter e.m.f. of the motor armature closes the accelerating contactor which cuts out the armature resistor, connecting the motor across the line.

Although the standard starter is supplied with thermal overload relays, starters without the relays are also available. The overload relays are the same as those



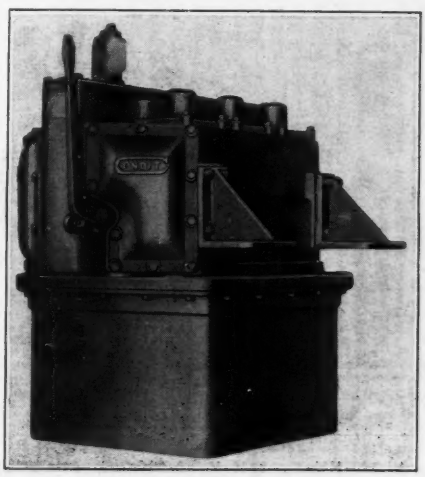
NEW CUTLER-HAMMER COUNTER E.M.F. STARTER

used in this company's a.c. automatic starters for small motors. They are of the fusible alloy type and can be made applicable to various size motors, by simply changing the heater coils.

New Oil Circuit Breakers for Underground Service

DESIGNED FOR underground distribution service up to 15,000 v., the Condit Electrical Manufacturing Corp. has recently placed on the market a new manhole oil circuit breaker of moderate interrupting capacity. This breaker, known as the type M-210, is of sturdy, water-tight construction throughout. A massive frame structure, heavily reënforced, supports the operating mechanism, bushing and current carrying parts. In the upper part of the frame, space is provided for two bushing type current transformers per pole in connection with which, up to six trip coils can be furnished. Individual tanks per pole are provided of welded steel plates. These are drawn up tightly against the frame by a strong bolt construction. A light, rapidly accelerating mechanism secures high-speed characteristics and easy operation.

Ample insulation is provided. Lead covered cables enter at the top through sleeves with wiped joints and terminate in a compound filled pot head inside the cir-



CONDIT MANHOLE OIL CIRCUIT BREAKER

cuit breaker from which, in turn, substantial porcelain insulators extend below the oil line. There are no exposed current carrying members above the oil line. The type M210 is furnished manually operated, 3-pole, single throw for 400 amp. at 15,000 v., non-automatic or full automatic (trip free) with an estimated interrupting capacity of 60,000 kv-a.

Gage with Resetting Device

HYDRAULIC RESETTING device gage made in 6, 6¾, 8½, 10 and 12-in. sizes has just been placed on the market by J. E. Lonergan Co., 211 Race St., Philadelphia, Pa. In this new model GHB, as it is known, the

NEW RESETTING GAGE

maximum hand is designed to be carried forward by the movement itself; it is stated that there is no drag whatso-ever on the pointer.

The maximum hand shows the highest pressure reached and resetting is controlled from outside but cannot be tampered with as the gage is equipped with lock and key.

New Cell Type Capacitors

ELECTRIC MACHINERY MANUFACTURING Co. of Minneapolis, Minn., has recently announced a new improved line of cell type capacitors for use in power factor

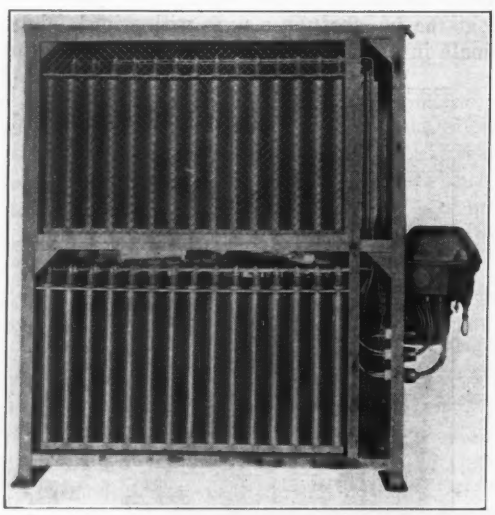


FIG. 1. A 360-KV-A., 2300-V., 3-PHASE, 60-CYCLE CELL TYPE CAPACITOR FOR INDOOR USE. ONE SCREEN IS REMOVED TO SHOW CONSTRUCTION

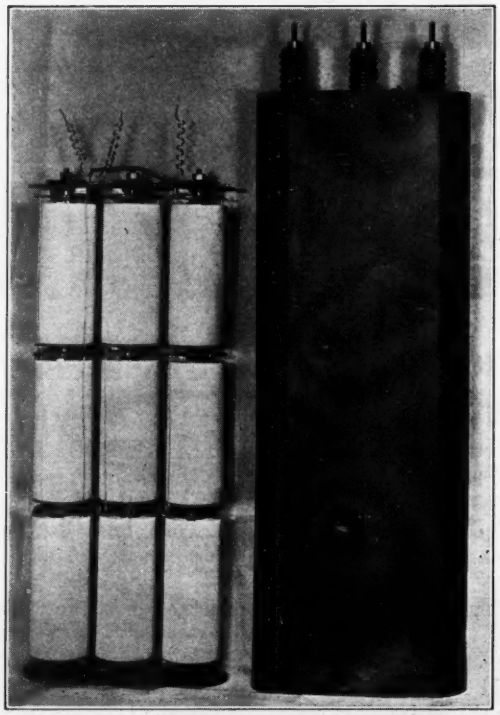


FIG. 2. THE STANDARD CELL USES NINE CAPACITOR ROLLS, RIGIDLY MOUNTED ON A RACK AND CONNECTED FOR 3-PHASE OR SINGLE-PHASE OPERATION

improvement. These capacitors are built for either indoor or outdoor use, the outdoor type capacitor being completely enclosed in a sheet steel housing.

This capacitor consists of an assembly of capacitor cells securely mounted on a rugged steel stand. Each cell is a complete capacitor unit, and by connecting two or more cells in parallel, any desired kv-a. capacity may be obtained.

Among the desirable features of the E-M cell type capacitor is the cylindrical roll, which is the working element in the capacitor cell. The cylindrical form of construction prevents undue mechanical stress on the tissue, thus insuring long life.

Individual capacitor rolls are mounted on a supporting rack and sealed under oil in the cell. The cell containers are substantially built from 18 gage sheet steel and have welded oil tight joints. Stands for holding the cells are of welded sheet steel construction.

Allis-Chalmers Builds 115,000-Kw. Generator

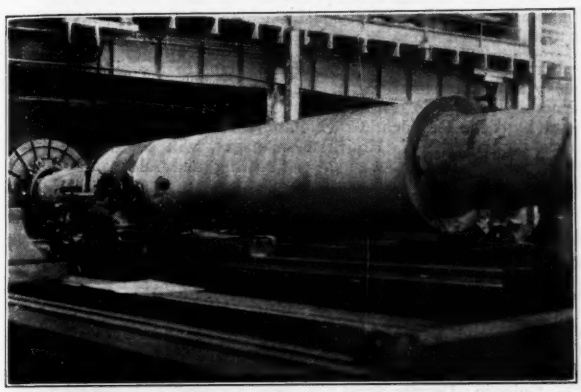
NEW LARGE UNITS have been developed during the past year by Allis-Chalmers Mfg. Co., Milwaukee, Wisc. as follows:

A 65,000-kw. unit for Waukegan Generating Co. This unit will operate with steam at 600 lb. gage steam pressure, 750 deg. F. total steam temperature, and 29 in. vacuum, and is a tandem compound single generator unit similar in general to the 50,000-kw. unit in the same station, except for size and the fact that the high pressure cylinder is designed for interstage reheating.

Unit of 60,000-kw. capacity for The Milwaukee Electric Railway and Light Co., Lakeside Station. The

operating conditions for this unit are 290 lb. gage steam pressure, 700 deg. F. total temperature, and 29¼ in. vacuum. This unit is of the single cylinder design, being the largest of this type thus far sold by the company.

Tandem-compound, 115,000-kw. single generator unit for Waukegan Generating Co. to operate with steam at 625 lb. gage steam pressure, 750 deg. F. total temperature, and 29 in. vacuum. This unit is similar in design to the 65,000-kw. unit mentioned above except that the great difference in size necessitates all new development. This unit is the largest single generator 1800 r.p.m. unit ever contracted for by any manufacturer.



ROTOR FORGING OF 115,000-KW. UNIT FOR WAUKEGAN

In the accompanying illustration is shown the rotor forging for the 115,000-kw., 1800-r.p.m. turbine-generator. This is said to be one of the largest steel forgings ever made; it is approximately 42 ft. long and weighs 269,000 lb. The photograph was taken in the plant of the Midvale Co., Philadelphia, where it was forged.

Industrial Groups Meet in Chicago in March

THIRD NATIONAL Materials Handling Meeting of the A. S. M. E. will be held at the Stevens Hotel, Chicago, March 5-6-7. Six sessions have already been arranged and a group of inspection trips to nearby plants is in course of preparation. The meetings will cover widely diversified subjects in Materials Handling and the shipment of merchandise. Included will be: Pneumatic Handling of Coal, Use of Portable Conveyors, Use of L.C.L. in Package Shipment, Economics of the Tractor and Trailer in Industrial Handling, Materials Handling as an Important Factor in Plant Maintenance, Laying Out Proper Materials Handling Systems, Successful Materials Handling Systems and Requirements of Manufacturers Pertaining thereto.

Also two symposiums, one on Shipment of Goods on Skid Platforms and the other on Safety in Materials Handling.

Speakers for subjects already assigned include Matthew W. Potts, New York, Willard Brinton, R. L. Lockwood, U. S. Department of Commerce, E. J. Barney, Frigidaire Corp., N. H. Preble, W. C. Stuebing, C. E. Johnson, Eastman Kodak Co., and others of like caliber and prominence.

National Industrial Exposition, to be held Mar. 2-8, will feature to a large extent materials handling equipment, supplies and accessories. The exhibitors in this group will include such prominent companies as The International Harvester Co., Northwest Engineering Co., Automatic Transportation Co., Louden Machinery Co., Lewis-Shepard Co., Clark Tructractor Co., Jervis B. Webb Co., The Whiting Corp., and many others of similar importance in the industry. A full list of exhibitors will be ready and published March 1, and a directory will be available at the Exposition at all times. Actual demonstration of materials handling will be given.

Program of the National Management Congress to be held in Chicago, March 3, 4 and 5, promises exceptional papers and speakers. Nine sessions have been arranged, opening with an address on Some Economic Aspects of Management in the Future and following with addresses on The Development of Organized Management, Science and Philosophy since Taylor, the main theme running through the entire conference being Organizing for Permanent Prosperity.

In the technical sessions, of which there will be six, subjects are: Progress in Distribution Methods, Simplification and Mechanization in the Administrative Field, Plant Maintenance, Wage Incentive Plans, Industrial Education and Training, and the Machine Age—readjustments in industry due to mechanization.

In this Congress also will be held the first meeting of the American Society of Mechanical Engineers' Committee on Elimination of Waste.

Death of Sherwood F. Jeter

SHERWOOD F. JETER, vice-president of the Hartford Steam Boiler Inspection & Insurance Co., Hartford, Conn., died on Tuesday, December 31, 1929. Mr. Jeter was born in Columbus, Ga., in 1872. After graduating at the Georgia School of Technology in 1893 with the degree of B. S. in mechanical engineering, he entered the electrical field, spent a year as electrician for the Mexican Telephone Co., and in 1898 joined the New Orleans department of the Hartford Steam Boiler Inspection & Insurance Co. as inspector of boilers. In 1906 he became mechanical engineer of The Bigelow Co. and in 1910 returned to the Hartford Steam Boiler Inspection & Insurance Co. as supervising inspector. In 1915 he was made chief engineer and later vice-president. He was a past vice-president and past manager of the A.S.M.E., served on the society's boiler code committee and was active in the work of the Hartford section.

Death of H. L. Monroe

HARRY L. MONROE, commercial vice-president of the General Electric Co. with headquarters at Chicago, died at Dallas, Tex., on January 7, following a long illness. Mr. Monroe completed 40 yr. of service with the company in September, 1928, six months after his election to the vice-presidency. Mr. Monroe was born in Parkersburg, W. Va., in 1869. He entered the employ of the company in 1888, with the Thomson-Houston Co. in Chicago. In 1890 he was transferred to the railway department and in 1894 became a salesman operating out of the Dallas office of the General Electric Co. He

was made manager of the railway department of the central district in 1905 and 8 yr. later was named district sales manager, and later district manager of the central district, with offices in Chicago.

Death of Arthur D. Pratt

ARTHUR D. PRATT, assistant advisory engineer of The Babcock & Wilcox Co., New York, died on December 31, at his home in New Jersey. He was 48 yr. old. He graduated at Princeton University in 1904, spent two years in graduate work at Massachusetts Institute of Technology and then entered the testing department of The Babcock & Wilcox Co. at Bayonne, N. J. Here he engaged in boiler testing and experimental work with power plant apparatus. In 1911, he was made assistant to the advisory engineer. He devoted his time to general boiler investigation and research.

News Notes

ENGINEERING SOCIETY OF WISCONSIN will hold its 22nd annual convention at the University of Wisconsin in Madison on February 20 and 21. A special session for the surveyors of the state will be held on Wednesday, February 19, at the same place. A joint meeting with the Technical Club of Madison will be held on the evening of February 21. L. F. Van Hagan is president of the society, which has over 400 members. R. S. Owen, of Madison, is secretary.

CARL E. GRUNSKY of San Francisco, past president of the American Society of Civil Engineers, was elected president of the American Engineering Council at the opening session of the annual meeting of the Council held at the Mayflower Hotel, Washington, January 10-11. Mr. Grunsky, who will serve during 1930 and 1931, succeeds Arthur W. Berresford of New York, past president of the American Institute of Electrical Engineers.

Vice-presidents were chosen as follows: L. B. Stillwell, New York, American Institute of Electrical Engineers; Major Gardner S. Williams, Ann Arbor, Mich., Detroit Engineering Society; O. H. Koch, Dallas, Tex., Technical Club of Dallas; L. P. Alford, New York, American Society of Mechanical Engineers. Dr Harrison E. Howe of Washington, representing the American Institute of Chemical Engineers, was reëlected treasurer. Lawrence W. Wallace of Washington continues as executive secretary, a post he has occupied since the formation of the Council as the public service body of the engineering profession under the presidency of Herbert Hoover in 1919.

POWER GENERATION COMMITTEE of the American Institute of Electrical Engineers, has appointed a sub-committee to investigate the question of whether members of the Institute, who are employed or connected with industries, feel that their interests are being served by the reports issued by the Power Generation Committee or the papers presented for which the committee is sponsor. All members interested in this matter are requested to communicate with Frederick A. Scheffler, 85 Liberty St., New York, N. Y.

ALLIS-CHALMERS MANUFACTURING CO. announces the establishment of a sales office at 633-634 Tennessee Electric Power Bldg., Chattanooga, Tenn. This office, with D. S. Kerr as representative in charge and A. I. Richardson, sales engineer, will operate as a branch of the Atlanta district office under the direction of Berrien Moore, district manager. This will serve the eastern and central territory.

J. E. N. HUME has been appointed assistant manager of the industrial department of the General Electric Co., and has been succeeded by C. F. Pittman as manager of the motor division of the industrial department.

TO CELEBRATE an addition to its plant, which in the last year has doubled in size, and to welcome new members of their organization, which during the same period has grown from 750 to 1150, employes of the Leeds & Northrup Co., 4901 Stenton Avenue, Philadelphia, Pa., held a minstrel show and dance in the ballroom of the Elks Club on Friday evening, December 13, 1929. The latest addition to the Leeds & Northrup Co. plant increased the floor space from about two to over four acres.

AT A MEETING of the Board of Directors of The Permutit Co., New York, held Monday, December 30, H. Kriegsheim, who has been president of the company for the past seven years, was appointed chairman of the board and W. Spencer Robertson, formerly secretary of the American Locomotive Co., was appointed president of the company. Mr. Kriegsheim will continue to take an active interest in the management of the company.

PURCHASE of the business of Dwyer Equipment Co., Chicago, makers of unit heaters, is announced by the C. A. Dunham Co., Chicago. The outstanding capital stock of the Dwyer Company was acquired by the Dunham Company. Lawrence P. Dwyer, president and Wm. J. Mauer, vice-president of Dwyer Equipment Co., join the C. A. Dunham organization. Mr. Dwyer becomes general manager of the unit heater division and Mr. Mauer, sales manager of that division, each to be located at the general offices of the Dunham Co., in its own building, 450 East Ohio St., Chicago, Ill. The Dwyer plant, now located in Chicago, will be moved to the newly constructed Michigan City factory of the Dunham Co. Certain brass parts will be made at the company's Marshalltown, Iowa foundry and machined at the company's plant in that city.

CHARLES E. WILSON, formerly assistant to the vice president, has been named manager of the merchandise department of the General Electric Co., Bridgeport, Conn., according to an announcement by Vice President C. E. Patterson. Mr. Wilson, who succeeds the late H. C. Houck as manager, will continue to have supervision of manufacturing, engineering and sales activities of the department.

ACCORDING TO a recent announcement by E. T. McCleary, president of Republic Iron & Steel Co., a great merger of several important steel companies has just been consummated. The new company is to be known as Republic Steel Corp. and Mr. McCleary will be its president. It will include: Republic Iron & Steel Co., Youngstown, Ohio, and its subsidiaries, Steel and Tubes, Inc., of Cleveland and Union Drawn Steel Co., Beaver Falls, Penna.; Central Alloy Steel Corp., Massillon and Canton, O., and subsidiaries; Berger Mfg. Co., Canton, and Interstate Iron & Steel Co., Chicago; Donner Steel Co., Inc., Buffalo, N. Y., and its subsidiary; Witherow Steel Co., Pittsburgh; Bourne-Fuller Co., Cleveland; Trumbull-Cliffs Furnace Co., Warren, O. Beside these, the Republic Research Co. will be included to further the experimental work of the company. It is stated that this consolidation may be only a step towards a larger one, which might include Youngstown Sheet & Tube Co. and Inland Steel Co.

NEW YORK EDISON and associated electric light and power companies will, during 1930, spend $76,848,053 for construction supplies and labor. The principal items of the budget are: Generating stations, $20,581,095; substations, $1,204,008; buildings and yards, $2,458,000; transmission and distribution, $50,250,950; miscellaneous, $2,354,000, of which transportation equipment will take $1,000,000.

MAVERICK CO. Water Improvement District, No. 1, Eagle Pass, Texas, has completed all details for its proposed hydroelectric power and irrigation projects, awarding a general contract for construction to Ulen & Co., 120 Broadway, New York. The work will consist of a water improvement canal running through the county; water for the system will be taken from the Rio Grande River, at a point about 35 mi. from Eagle Pass, Texas, where a hydroelectric power plant will be built, with an extensive transmission system. This feature of the program is expected to cost approximately $1,000,000. The improvement District has contracted with the Central Power & Light Co., San Antonio, Texas, for the supply of water for the hydroelectric installation. The canal system will be used to irrigate about 75,000 acres of land in the Eagle Pass territory, and is estimated to cost about $5,000,000. The entire program is scheduled for completion in 24 mo.

THE BOSTON & ALBANY RAILROAD CO., Boston, Mass., has approved plans for the construction of a new power plant at Beacon Park, Allston, to be used in connection with a new engine house and shops now in course of erection at that place. The power plant will be equipped with two 445-hp. Stirling watertube boilers, which will operate at 180 lb. working pressure. The new plant will use pulverized coal as fuel, and two 4000-lb. pulverizers will be installed on the firing floor. The power plant will be equipped with overhead coal bunkers to facilitate coal handling. A radial brick stack 225 ft. high will be built. The entire program, including shops, will represent an investment of close to $1,000,000.

UNITED STATES CIVIL SERVICE COMMISSION announces open competitive examinations for local and assistant inspector of boilers and local and assistant inspector of hulls. Applications for these must be on file with the Civil Service Commission at Washington, D. C., not later than March 4.

The examinations are to fill vacancies in the Steamboat-Inspection Service, and in positions requiring similar qualifications. The entrance salaries are $3200 a year for local inspectors, and $2900 a year for assistant inspectors. Higher-salaried positions are filled through promotion.

Full information may be obtained from the United States Civil Service Commission, Washington, D. C., or from the secretary of the United States Civil Service Board of Examiners at the post office or customhouse in any city.

PRODUCTION OF ELECTRIC POWER by public utility power plants for November, 1929, reached a total of 8,240,407,000 kw-hr. This is an increase of 6 per cent over the output for November, 1928. Of the total amount, 5,598,244,000 kw-hr. were produced by fuel and the remainder, 2,642,163,000 kw-hr., were produced by water power.

DECEMBER SALES of mechanical stokers, as reported to the Department of Commerce by the 10 leading manufacturers in the industry, totaled 79 stokers under boilers with a total horsepower of 44,976, as compared with 107 stokers of 39,469 boiler hp. in November and 102 of 49,212 hp. in December, 1928. Sales for the year amounted to 1716 stokers under boilers of a total horsepower of 599,585. Of this total, 706 stokers were installed under fire tube boilers of 102,515 hp., while 1010 stokers were installed under water tube boilers of 497,070 hp.

Books and Catalogs

ELEMENTS OF ENGINEERING THERMODYNAMICS; by James A. Moyer, James P. Calderwood and Andrey A. Potter; published by John Wiley & Sons, 440 Fourth Ave., New York, N. Y.; 6 by 9 in., cloth, 174 pages; price, $2.50.

Fourth edition, with many changes and with the chapters on vapor cycles and flow of fluids entirely rewritten. The book is written so that the basic principles of the subject and the practical application of these principles are closely related. Ten chapters ranging from principles and definitions to the application of these principles to all types of engines, compressed air and refrigeration equipment are included.

SEPARATORS for removing water, oil and solids from currents of live or exhaust steam and from air or other gases, are described in a large size 92-page bulletin issued by Cochrane Corp., Philadelphia, Pa. Numerous tables and diagrams give sizes and dimensions of separators for various services, such as live steam, exhaust steam and air and gas lines, including receiver separators and steam purifiers for removing water and solids from steam delivered by high rating boilers before it enters the superheater and steam mains. The publication presents information on the installation of steam and oil separators, the laying out and flow resistance of pipe lines, the selection of cylinder lubricants, testing for oil in condensate and other related subjects.

NINTH ANNUAL REPORT of the Federal Power Commission for the fiscal year ending June 30, 1929, has just been issued. Part I of this report discusses the increase in electric power production in the United States, distribution of water power resources, public cooperation, regulations, noteworthy developments, Colorado River situation, personnel, and gives a detailed summary of the year's work of the engineering division. The latter item covers permits and licenses, withdrawals, declarations of intentions and allied matters. Discussion of the accounting, legal and operations divisions follows. Part II gives various appendixes to commissions' reports, terms of permits and licenses issued, statements of moneys received and the like. The report is for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., price 20c.

SURFACE CONDENSERS, Leaflet No. 20424, has recently been published by Westinghouse Electric and Mfg. Co. and should be of interest to operators of industrial plants and public utility stations. The leaflet contains a number of pictures and drawings, describes in detail the construction of the condensers, and lists their distinctive features.

CHARTS FOR THE Selection of Centrifugal Pumps are included in Bulletin 200 issued by the Goulds Pumps, Inc., Seneca Falls, N. Y. This particular bulletin refers to horizontally-split, enclosed-impeller, single-stage, double-suction pump and later bulletins will be issued to cover other types. The use of the selection charts is fully explained in the bulletin, covering ranges from 10 up to 20,000 ga. per min., heads up to 1000 ft. and showing the size of pump to use under each set of conditions, together with the power required to drive it. Construction and details of various sizes and types of Goulds pumps are also shown.

THE LARGEST Steam Generating Units in the World is the title of a pamphlet issued by Combustion Engineering Corp., 200 Madison Ave., New York City, describing three units in the East River Station of the New York Edison Co., each to generate 800,000 lb. of steam an hour. Performance of the first unit over a period of 2 mo. indicates ability to furnish 1,000,000 lb. of steam an hour. Pulverized coal, fin furnaces, water screens, air preheaters and integral economizers are some of the features. Copies of the pamphlet may be obtained by request to the Combustion Engineering Corp.

BULLETIN 394 of Zelnicker, St. Louis, lists a wide variety of power plant and industrial plant equipment including steam, electrical, oil and gasoline engines, cars, tanks, tools and cranes.

C-E MULTIPLE RETORT STOKERS for super stations are fully illustrated and described in a new catalog, MR-2, issued by Combustion Engineering Corp., 200 Madison Ave., New York City. The catalog was produced by the Aquatone process and is a beautiful example of the engravers and printers art, fine detail of halftones showing clearly although English finish paper is used. Full details of this design of stoker are given as well as its operation and adaptation to various types of boilers and settings. Copies of the catalog may be had on request.

PROTECTIVE COATINGS for preventing corrosion of power plant equipment is the subject of Bulletin No. 1170 just issued by the Dampney Co. of America, Hyde Park, Boston, Mass. This discusses corrosion and the applications of Apexior designed to prevent it. In Bulletin 1181, recommendations regarding the application of Apexior protective coatings to new water-tube boilers, water walls and economizers are given.

VM-Type bent tube boilers, designed for limited space, where the headroom is low, are described and illustrated in a folder with table of dimensions issued by Combustion Engineering Corp., 200 Madison Ave., New York City.

OBNOXIOUS VAPOR CONDENSERS, their construction and operation, are described in Bulletin 4-R, just issued by Schutte & Koerting Co., Philadelphia, Pa. These are designed to condense fumes and vapors that are generated in industrial processes and are often readily absorbed in water. Thus the simplest and most satisfactory way to remove them, it is stated, is by water spray condensers. These are supplied in capacities varying with pressure and vacuum desired up to 5000 c.f.m. of gas and they operate at water pressures of from 15 to 40 lb.

SURFACE AIR COOLERS are described in bulletin GEA-226A recently issued by the General Electric Co., Schenectady, N. Y. This bulletin, which supersedes GEA-226 describes the design and construction of surface air coolers and shows their application in power plants.

QUIGLEY Triple-A Protective Coatings in various colors are shown by a color chart and illustrated text in a recent folder issued by Quigley Furnace Specialties Co., Inc., 56 W. 45th St., New York, N. Y.

NEEMES GRATES are completely described and illustrated in a 16-page bulletin No. 109 just issued by Neemes Foundry, Inc., Troy, N. Y. This bulletin supersedes the company's bulletin No. 103. Various parts of the grates are shown in detail and the assembly is described and well illustrated.

WESTON HEAT FLOW METER is described and illustrated in a 12-page bulletin by Weston Electrical Instrument Corp., Newark, N. J. The meter consists of a sensitive millivoltmeter and three thin rubber belts, one of which contains a large number of thermocouples brought out to binding posts at the end of the belt for connection to the meter. The belts are wrapped around a pipe or other equipment from which the heat flow is to be measured and the flow is read directly in B.t.u. per hour per sq. ft. on the millivoltmeter.

SELSYN-OPERATED DEVICES for remote indication and record of liquid level, flow, pressure, temperature, draft, position and other factors are described in Bulletin 110 by Bailey Meter Co., Cleveland, Ohio. In the various Bailey meters, means are provided whereby the motion of an element of the meter actuates the Selsyn generator, which then transmits its indications electrically to a Selsyn receiver at a considerable distance, which may sometimes be as much as 10 mi. Detailed drawings of the various devices are presented with a clear explanation of how they operate.

DETROIT JUNIOR STOKER, an automatic stoker for apartments, office buildings, hotels, schools and industrial houses, is described in a recent folder by Detroit Stoker Co., General Motors Building, Detroit, Mich. This stoker is of the plunger feed type and incorporates a built-in blower, reduction gear and the necessary adjusting devices all in one unit.

ANDALE ROTREX STRAINER, a rotary device designed for use where the quantity of water to be handled is extremely large or where the dirt in the water accumulates rapidly, is described in Bulletin 229 by Andale Company, 1600 Arch St., Philadelphia, Pa. It is supplied in sizes from about 4000 g.p.m. to 70,000 g.p.m.

THIS EXPANDING AGE is the title of a 32-page bulletin issued by the Fulton Sylphon Co., Knoxville, Tenn. This presents a discussion by F. Romer showing how many interesting applications of the Fulton Sylphon seamless metal bellows affect everyday life.

Power Plant Construction News

Ala., Birmingham—The Birmingham Water Works Co. plans extensions and improvements in system, including the installation of pumping machinery and auxiliary equipment, reported to cost more than $200,000. H. H. Horner is vice president.

Calif., Reseda—The Union Ice Co., San Francisco, has acquired property at Reseda, and plans construction of ice-manufacturing plant, reported to cost more than $50,000, with equipment.

Calif., San Francisco—The Pacific Gas & Electric Co., 245 Market Street, is having plans drawn for a steam-operated electric generating plant on Twenty-third Street, to cost about $450,000.

Conn., New London—The Southern New England Ice Co., Hartford, Conn., has filed plans for a one-story ice-manufacturing plant on Garfield Avenue, near Jefferson Avenue, 100x 168 ft., to cost more than $75,000, with equipment. The R. B. Engineering Corporation, 11 West Forty-second Street, New York, is engineer.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams Street, has filed plans for a one-story addition to power substation at the rear of 624-36 Kolmar Avenue, to cost about $45,000. The company has acquired property on South Wabash Avenue for another substation, for which plans will soon be drawn.

Ill., Monmouth—Electric power equipment will be installed in proposed new local plant for dry milk manufacture, to be constructed by a new company now being formed by M. U. Britton, Holliday Building, Monmouth, and associates, entire project to cost about $200,000.

Ind., Gary—The National Steel Corporation, Weirton, W. Va., comprising a recent merger of the Weirton Steel Co., and other interests, plans installation of electric power equipment in proposed new mill at Gary, where a tract of 1000 acres of land has been acquired, entire project to cost over $30,000,000. A power house will be built. Ernest T. Weir is chairman of the board.

Ind., Richmond—The Department of Electric Light and Power, 32 South Eighth Street, is planning extensions and improvements in municipal electric light and power plant to cost more than $350,000. D. C. Hess is general superintendent.

La., De Quincy—The Acme Products Co. plans installation of electric power equipment in connection with proposed expansion program at local turpentine plant, entire project to cost more than $500,000.

Mich., Battle Creek—The Clark Tructractor Co., Springfield Place, plans installation to industrial truck manufacturing plant, entire project to cost about $70,000.

Mich., Detroit—The Detroit Public Lighting Commission, 138 East Atwater Street, is considering the construction of a one-story power substation near Joy Road, reported to cost more than $50,000, with equipment. Smith, Hinchman & Grylls, Marquette Building, are architects and engineers.

Mich., Grand Blanc—The Superior Felt Products Co. plans installation of electric power equipment in connection with proposed rebuilding of portion of mill recently destroyed by fire with loss of about $100,000.

Mo., Ferguson—The Universal Match Co., Ferguson, plans installation of electric power equipment in connection with proposed rebuilding of portion of plant destroyed by fire, Jan. 6, with loss reported in excess of $300,000.

Miss., Laurel—The Eastman-Gardiner Hardwood Co. is said to be planning the installation of boiler plant equipment in connection with proposed rebuilding of portion of mill, recently destroyed by fire with loss reported at close to $60,000.

N. Y., Brooklyn—The Board of Education, Park Avenue and Fifty-ninth Street, will install motors, controls and other industrial electrical equipment in proposed new Brooklyn Technical High School to cost about $5,000,000. Walter C. Martin, architect for the board, is completing plans.

N. Y., College Point, L. I.—Walter Kidde Constructors, Inc., Engineers and Builders, New York City, are receiving proposals for a six hundred horsepower boiler with stoker and auxiliary equipment for boiler plant addition at the I. B. Kleinert Rubber Co., College Point, Long Island.

Ohio, Cincinnati—The Cincinnati Tool Co., 1951 Waverly Place, plans installation of electric power equipment in proposed addition to plant to cost close to $100,000.

Ohio, Cleveland—The Fairmont Creamery Co., 608 Bolivar Road, plans installation of electric power equipment in proposed five-story ice cream manufacturing plant on West Seventeenth Street, estimated to cost close to $500,000.

Ohio, Dayton—The Duriron Co., Findlay Street, plans installation of electric power equipment in proposed addition to iron and metallurgical plant to cost more than $200,000. Geyer & Neuffer, Ludlow Arcade, are architects.

Okla., Hulbert—The Public Service Co., Tulsa, is said to be planning the construction of a steam-operated electric generating plant in the vicinity of Hulbert to cost close to $100,000, with equipment; extensions will be made in transmission lines.

Ore., McMinnville—The Nestle's Food Co. plans extensions and improvements in boiler plant at local factory including installation of an automatic oil firing system and accessories. Ray Bush is manager at the plant.

Pa., Carnegie—The Superior Paper Products Co., Carnegie, plans installation of power equipment in proposed new plant to cost about $140,000. Braziell & Anderson, 309 Fourth Avenue, Pittsburgh, Pa., are architects.

Pa., New Britain—The W. P. Cameron Co., 4850 North Mascher Street, Philadelphia, Pa., engineer, is preparing plans for a boiler plant in connection with new hosiery mill at New Britain, for a company whose name is temporarily withheld, entire project to cost over $50,000.

Pa., Philadelphia—Lit Brothers, Inc., Eighth and Market Streets, is having plans prepared for a one-story and basement power plant for department store service, estimated to cost $200,000. Simon & Simon, Fidelity Philadelphia Building, are architects.

Pa., Swissvale—The Wubco Battery Co. plans installation of electric power equipment in proposed addition to plant to cost about $150,000. Company is a subsidiary of the Electric Auto Lite Co., Toledo, Ohio. J. L. Rupp is president.

S. C., McClellanville—The South Carolina Power Co., Charleston, S. C., has secured a franchise at McClellanville, and plans construction of a steam-operated electric generating plant and transmission system.

Texas, Big Springs—The Texas & Pacific Railway Co., Dallas, Texas, has approved plans for a one-story steam power plant, 46x100 ft., at proposed new locomotive shops at Big Springs, entire project to cost more than $100,000.

Texas, Dallas—The Crystal Carbonic Laboratory, Atlanta, Ga., a subsidiary of the Coca Cola Co., Atlanta, plans installation of electric power equipment in proposed carbonic gas plant on Alamo Street, North Dallas, entire project to cost about $100,000. William N. Cochran is vice president and general manager.

Texas, El Paso—The American Smelting & Refining Co. is said to be planning the installation of electric power equipment in connection with extensions and improvements in local smelting works, entire project to cost $100,000. B. N. Rickard is general manager of plant.

Wash., Seattle—The Department of Lighting, County-City Building, is planning extensions and improvements in steam-operated electric power plant at Lake Union with installation of equipment to increase capacity to about 10,000 kw.

Wis., Green Bay—The Verifine Dairy Products Co., Cedar Street, is having plans prepared for a one-story power house at its factory, reported to cost about $35,000, with equipment. E. A. Juul, 601 North Sixth Street, Sheboygan, Wis., is engineer.

Wis., Milwaukee,—The Hill-Hubbell Co. 105 West Adams Street, Chicago, Ill., plans installation of electric power equipment in proposed paint and varnish manufacturing plant at Hopkins and Thirty-fifth Street, Milwaukee, entire project to cost about $85,000.

Wis., West Allis—The Unit Corporation of America, Inc., 84 East Wisconsin Avenue, is said to be planning an addition to boiler plant at tractor accessory manufacturing plant, estimated to cost over $40,000, with equipment.

Wis., West Milwaukee—The Harnischfeger Corporation plans installation of electric power equipment in proposed multi-story addition to machinery manufacturing plant, entire project to cost more than $150,000.